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on The Manual of Uniform
Traffic Control Devices

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WEBSITE PUBLICATION
Revised Edition of Part 6 of the Michigan Manual of Uniform Traffic Control Devices

Publication of the 2001 Part 6 of the Michigan Manual of Uniform Traffic Control Devices (MMUTCD) has been completed. Therefore, reference to its use in Maintaining Traffic Special Provisions shall be made for all contract work which is to be let in June 2001, and later. Other special provisions, contract documents, organization specifications and procedures, and documents which refer to the MMUTCD, should be edited to reflect this new edition.

The most significant change is the reintroduction of English units as the primary measurement, while including and updating metric measurements. Other changes in this revision include the addition of the Traffic Fines Doubled in Work Zones signs, the operation of No Passing Zone signs and markings in selected work zones, the inclusion of updated traffic regulator signs and clothing information, new reference to NCHRP Report 350, plus updated tables and graphics.

Two sections to note are 6G and 6H. These sections were updated to provide more uniformity and consistency in guidance and optional information pertaining to Michigan work zones. Also, two blank pages for FIELD NOTES were included to Section 6H, in advance of Figures 6-10 to 6-36, to provide a more "user friendly" document.

Again, I would like to thank the State Advisory Committee and members of MDOT who offered their contributions to this revision.

***SPECIAL NOTE - Errata / Revisions to the Part 6, January 2001 Printed Edition are listed with this website edition. Changes to this website publication require approval of the State Advisory Committee.**

ERRATA of the January, 2001 Printed Edition, PART 6 of the MMUTCD-

MAY, 2001

THESE CHANGES HAVE BEEN MADE TO THE PART 6 WEBSITE

Page 6E-5, Figure 6-4, Note 3 line 3, "one **hand** with the bottom of the sign.."

Page 6F-2, Figure 6-5, Urban District-Dimension arrows corrected to edge and bottom heights

Page 6H-13, Figure 6-13- Traffic Regulator (Flagger) symbols repositioned to edge of roadway

Page 6H-26, #6 Change from "sued" to used

Page 6H-27, #2 Change from "strets" to streets

Page 6H-28, #3 Change from "adequte" to adequate

Page 6H-31, #5 Change from 3" to 3'

Page 6H-32,#3 Change from "fo" to for
#6 Change from "fo" to of

PREFACE

Part 6 of the Michigan Manual of Uniform Traffic Control Devices (MMUTCD) is produced here as a separate publication to meet the special needs of those involved in traffic control during construction, maintenance operations, utility work or emergencies. The standards, policies and recommendations contained in this booklet reflect that which was published by the Federal Highway Administration (FHWA) in September 1993. This booklet becomes the third revision to the 1994 Edition of the MMUTCD which was published in the fall of 1994 .

Part 6 of the MMUTCD contains far more typical diagrams and describes the warning needs for work in several categories such as mobile, short duration, or stationary for differing lengths of time. It also describes the needs for warnings when the work is taking place off the roadway, on the shoulder or in the roadway. It also makes recommendations on the differing need for warnings depending on the type of roadway, speed of the traffic, or the environment through which the roadway passes.

The need for standard traffic controls is especially acute during roadway maintenance operations, utility activities, emergencies or reconstruction. Abnormal conditions unfamiliar to the everyday driver are usually the rule, and therefore all drivers are dependent on good design, proper placement, and uniformity of traffic control devices to direct and guide motorists safely and efficiently around or through the work zones. The constantly shifting and changing nature of work zone activity on or adjacent to the roadway requires frequent readjustments of traffic control devices to handle new situations. Therefore, pavement markings, channelizing devices and other traffic control devices in work zones are a continuous responsibility of officials having authority over the roadway in their jurisdiction.

This booklet is made available at no charge from the Michigan Department of Transportation (MDOT) Region offices, Transportation Service Centers, or the Lansing office. This new revised Part 6 will be issued to all holders of the 1994 Edition of the MMUTCD on record. The MMUTCD and Part 6 are available from the Michigan Department of Transportation, Cashier's Office, P. O. Box 30648, Lansing MI, 48909-8148. The cost the 1994 Michigan Manual is $35.00 plus tax, if applicable. Checks must be made payable to the State of Michigan, and a street address must be provided for delivery as the manuals are shipped by UPS.

Part 6 is also available on MDOT's internet website- www.michigan.gov/mdot

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PART 6

TRAFFIC CONTROLS FOR STREET AND HIGHWAY CONSTRUCTION, MAINTENANCE, UTILITY, AND INCIDENT MANAGEMENT OPERATIONS

6A. INTRODUCTION

During any time the normal function of a roadway is suspended, temporary traffic control planning must provide for continuity of function (movement of traffic, pedestrians, transit operations, and access to property/utilities). The location where the normal function of the roadway is suspended is defined as the work space. The work space is that portion of the roadway closed to traffic and set aside for workers, equipment, and materials. Sometimes there may be several work spaces within the project limits. This can be confusing to drivers because the work spaces may be separated by several miles. Each work space should be adequately signed to inform drivers of what to expect.

Effective temporary traffic control enhances traffic safety and efficiency, regardless of whether street construction, maintenance, utility work, or roadway incidents are taking place in the work space. Effective temporary traffic control must provide for the safety of workers and road users. At the same time, it must provide for the efficient completion of whatever activity suspended normal use of the roadway.

No one set of signs or other traffic control devices can typically satisfy all conditions for a given project. At the same time, defining detailed standards that would be adequate to cover all applications is simply not practical. Part 6 displays several diagrams that depict common applications of standard temporary traffic control devices. The traffic control selected for each situation should be based on type of highway, traffic conditions, duration of operation, physical constraints, and the nearness of the work space to traffic.

Traffic control plans and devices may be adopted by the governmental body having jurisdiction for guiding traffic. The plans and devices should follow the principles set forth in this Part but may deviate from the typical drawings to allow for conditions and requirements of a particular site or jurisdiction.

The criteria of this part are intended to apply to both rural and urban areas. Rural highways are normally characterized by lower volumes, higher speeds, fewer turning conflicts, and fewer conflicts with pedestrians. Urban street traffic is typically characterized by relatively low speeds, wide ranges in traffic volume, narrower roadway lanes, frequent intersections, significant pedestrian traffic, and more roadside obstacles.

Concern for traffic safety, worker safety, and efficiency of traffic movement form an integral element of every temporary traffic control zone, from planning through completion of work activity. The control selected must permit efficient maintenance and construction of roadways and roadway appurtenances simultaneously.

6B. FUNDAMENTAL PRINCIPLES

All traffic control devices used on street and highway construction, maintenance, utility, or incident management (temporary traffic control) operations shall conform to the applicable specifications of this manual.

Special plan preparation and coordination with transit and other highway agencies, police and other emergency units, utilities, schools, railroads, etc. may be needed to reduce unexpected and unusual traffic operation situations.

During temporary traffic control activities, commercial vehicles may need to follow a different route from automobiles because of bridge, weight, clearance, or geometric restrictions. Also, vehicles carrying hazardous materials shall follow a route designated by the State Fire Marshal when obtaining a permit to transport such materials as stated in Section 29.5d of the Michigan Vehicle Code**.**

The following listing contains principles and procedures which experience has shown enhanced safety of motorists and workers in temporary traffic control areas. These principles and procedures provide a guiding philosophy of good temporary traffic control used in work zones for the practitioner. They do not establish specific standards and warrants. These warrants and standards are addressed individually in the succeeding sections of this part.

6B-1 Traffic safety in temporary traffic control areas

Traffic safety in temporary traffic control areas should be an integral and high-priority element of every project from planning through design and construction. Similarly, maintenance and utility work should be planned and conducted with the safety of motorists, pedestrians, and workers kept in mind at all times. Formulating specific plans for incident management, traffic control is difficult because of the variety of situations that can arise. Nevertheless, plans should be developed in sufficient detail to provide safety for motorists, pedestrians, workers, and enforcement/emergency personnel and equipment.

A. The basic safety principles governing the design of permanent roadways and roadsides should also govern the design of temporary traffic control zones. The goal should be to route traffic through such areas using geometrics and traffic control devices comparable to those for normal highway situations.

B. A traffic control plan, should be prepared and understood by all responsible parties before the signing is installed. The detail of the plan should be appropriate to the complexity of the site, type of work, volume, speed of passing traffic, and time of project duration. Any changes in the traffic control plan should be approved by an official trained in safe traffic control practices.

6B-2 Traffic movement should be inhibited as little as practicable.

A. Traffic control in work and incident sites should be designed on the assumption that drivers will reduce their speeds only if they clearly perceive a need to do so. Reduced speed zoning should be avoided as much as practical.

B. Frequent and abrupt changes in geometrics—such as lane narrowing, dropped lanes, or main roadway transitions requiring rapid maneuvers—should be avoided.

C. Provisions should be made for the safe operation of work or incident management vehicles, particularly on high-speed, high-volume roadways.

D. Work time should be expedited to minimize lane or road closure time to reduce exposure.

E. Pedestrians should be provided with access and safe passage through the temporary traffic control zone at all times.

F. Roadway occupancy should be scheduled during off-peak hours and, if necessary, night work should be considered.

6B-3 Drivers and pedestrians should be guided in a clear and positive manner while approaching and traversing the temporary traffic control zone.

A. Adequate warning, delineation, and channelization by means of proper pavement marking, signs, or use of other devices that are effective under varying conditions of light and weather should be provided where appropriate to assure the driver and pedestrian of positive guidance before approaching and while passing through the work area.

B. Signs, pavement markings, channelizing devices, delineators, and other traffic control devices that are inconsistent with intended travel paths through long-term work spaces should be removed. In short-duration and mobile work spaces where retained permanent devices are inconsistent with intended travel paths, attention should be given to devices that highlight or emphasize the appropriate path.

C. Traffic regulators procedures, when used, can provide positive guidance to drivers traversing the temporary traffic control area. Traffic regulators should be employed only when all other methods of traffic control are inadequate to warn and direct drivers.

6B-4 To ensure acceptable levels of operation, routine inspection of traffic control elements should be performed.

A. Individuals who are trained in the principles of safe traffic control should be assigned responsibility for safety at work sites. The most important duty of these individuals is to ensure that all traffic control measures implemented on the project are necessary, conform to the traffic control plan, and are effective in providing safe conditions for motorists, pedestrians, and workers.

B. Modification of traffic controls or working conditions may be required to expedite safe traffic movement and to promote worker safety. It is essential that the individual responsible for safety have the authority to control the progress of work on the project with respect to obtaining safe conditions, including the authority to modify conditions or halt work until applicable or remedial safety measures are taken.

C. Temporary traffic control areas should be carefully monitored under varying conditions of traffic volume, light, and weather to ensure that traffic control measures are operating effectively and that all devices used are clearly visible, clean, and in good repair.

D. When warranted, an engineering analysis should be made (in cooperation with law enforcement officials) of all accidents occurring in temporary traffic control zones. Temporary traffic control zones and accident records should be monitored to identify and analyze traffic accidents or conflicts. For example, skid marks or damaged traffic control devices may indicate the need for changes in the traffic control.

E. All traffic control devices should be removed when no longer needed. When work is suspended for short periods, advance warning signs that are no longer appropriate shall be removed, covered, or turned, and other inappropriate devices removed from the work area so they are not visible to drivers.

6B-5 Attention to roadside safety maintenance is required during the life of the temporary traffic control zone because of the increase in accident potential.

A. To accommodate run-off-the-road incidents, disabled vehicles, or emergency situations, it is desirable to provide an unencumbered roadside recovery area.

B. Channelization of traffic should be accomplished by pavement markings, signs, and/or lightweight channelizing devices that will yield when hit by errant vehicles.

C. Whenever practical, equipment, workers' private vehicles, materials, and debris should be stored in such a manner as not to be vulnerable to run-off-the-road vehicle impact.

D. Pedestrian paths through the temporary traffic control zone should be protected to minimize pedestrian exposure to errant vehicles.

6B-6 Training

Each person whose actions affect temporary traffic control zone safety from upper-level management personnel through field personnel should receive training appropriate to the job decisions each is required to make. Only those who are trained in safe traffic control practices, and who have a basic understanding of the principles established by applicable standards and regulations (including those of the MMUTCD), should supervise the selection, placement, and maintenance of traffic control devices in work and incident management areas.

6B-7 Authority

The control of traffic through work areas is an essential part of street and roadway construction, utility and maintenance operations. For these operations there must be adequate legislative authority for the implementation and enforcement of needed traffic regulations, parking controls, speed zoning, and incident management. Such statutes must provide sufficient flexibility in the application of traffic control to meet the needs of changing conditions in work areas.

6B-8 Public Relations

Maintaining good public relations is necessary. The cooperation of the various news media in publicizing the existence of and reasons for work sites can be of great assistance in keeping motorists well informed.

6C. TEMPORARY TRAFFIC CONTROL ELEMENTS

6C-1 TRAFFIC CONTROL PLANS

Traffic Control Plans (TCP's) play a vital role in providing continuity of safe and efficient traffic flow, to the extent interruptions in normal flow are necessary for temporary traffic control operations or other events that must temporarily disrupt normal traffic flow. Important auxiliary provisions that cannot conveniently be specified on project plans can easily be incorporated into Special Provisions with the TCP.

A TCP describes traffic controls to be used for facilitating vehicle and pedestrian traffic through a temporary traffic control zone. The plan may range in scope from being very detailed, to merely referencing typical drawings contained in the MMUTCD, standard approved highway agency drawings and manuals, or specific drawings contained in contract documents. The degree of detail in the TCP depends entirely on the complexity of the situation, and TCP's should be prepared by persons knowledgeable about the fundamental principles of temporary traffic control and the work activities to be performed.

Traffic control planning requires forethought. Provisions may be incorporated into the project bid documents that enable contractors to develop alternate traffic control plans which may be used only if the responsible agency finds they are as good as those provided in the plans/specifications. For maintenance and minor utility projects that do not require bidding, forethought must be given to selecting the best traffic control before occupying the temporary traffic control zone. Also, coordination should be made between projects to ensure that duplicate signing is not used and to ensure compatibility of traffic control between adjacent projects.

Modifications of TCP's may be necessary because of changed conditions or determination of even better ways of handling traffic safely and efficiently, while permitting efficient temporary traffic control activities to progress.

6C-2. DEFINITIONS OF TEMPORARY TRAFFIC CONTROL ZONE COMPONENTS

The temporary traffic control zone includes the entire section of roadway between the first advance warning sign through the last traffic control device, where traffic returns to its normal path and conditions. Most temporary traffic control zones can be divided into four areas: the advance warning area, the transition area, the activity area, and the termination area. Figure 6-1 illustrates these four areas.

The four components that constitute a temporary traffic control zone are described in the order that drivers encounter them. They include the following:

A. Advance Warning Area

In the advance warning area, drivers are informed of what to expect. The advance warning may vary from a single sign or flashing lights on a vehicle to a series of signs in advance of the temporary traffic control zone transition area. On roadways, where the posted speed is 45 mph (70 km/h) or greater, signs may be placed from 450 ft to ½ mile (135-800 m) or more before the temporary traffic control zone. The true test of adequacy of sign spacing is to evaluate how much time the driver has to perceive and react to the condition ahead. In this regard, the use of speed, roadway condition, and related driver expectancy must be considered in order to drive a practical sign spacing distance. As a guide, Table 2-1 in Section 2C-3 of the MMUTCD should be used in conjunction with consideration of actual or anticipated field conditions. For effective placement of warning signs one may use the following Table 6-1 as a guide:

TABLE 6-1 Advance Sign Spacing Distances "D"

SPEED MPH	DISTANCE Ft	(m)
25	250	(76.2)
30	300	(91.4)
35	350	(106.7)
40	400	(121.9)
45	450	(137.2)
50	500	(152.4)
55	550	(167.6)
60	600	(182.9)
65	650	(198.1)
70	700	(213.4)

B. Transition Area

When redirection of the driver's normal path is required, traffic must be channelized from the normal path to a new path. This redirection is intended to occur at the beginning of the transition area. In mobile operations, this transition area moves with the work space. Transition areas usually involve strategic use of tapers, which are discussed in more detail in Section 6C-3.

C. Activity Area

The activity area is an area of roadway where the work takes place. It is composed of the work space and the traffic space, and may contain one or more buffer spaces.

1. Work Space

The work space is that portion of the roadway closed to traffic and set aside for workers, equipment, and material. Work space may be fixed or may move as work progresses. Long-term work spaces are usually delineated by channelizing devices or shielded by barriers to exclude traffic and pedestrians.

2. Traffic Space

The traffic space is the portion of the roadway in which traffic is routed through the activity area.

3. Buffer Space

The buffer space is an optional feature in the activity area that separates traffic flow from the work activity and provides recovery space for an errant vehicle. Neither work activity nor storage of equipment, vehicles, or material should occur in this space. Buffer spaces may be positioned longitudinally and laterally, with respect to the direction of traffic flow.

a. Longitudinal Buffer Space

The longitudinal buffer space may be placed in the initial portion of a closed lane in advance of the work space, as shown in Figures 6-1 and 6-2. When a protection vehicle is placed in advance of the work space, only the space upstream of the vehicle constitutes the buffer space.

The longitudinal buffer space, as depicted in Figure 6-2, should be used where a closed lane separates opposing traffic flows. Typically, it is formed as a traffic island and defined by channelizing devices.

A guide for the length of longitudinal buffer space is shown in Table 6-2. The length may be adjusted to satisfy individual agency needs.

b. Lateral Buffer Space

A lateral buffer space as shown in Figure 6-1 may be used to separate the traffic space from the work space. A lateral buffer space also may be used between two travel lanes, especially those carrying opposing flows. The width of the lateral buffer space should be determined by engineering judgment.

4. Incident Management Vehicle Storage Space

When work occurs on a high-volume, highly congested facility in an urban area, it is optional to allow space to store emergency vehicles (e.g., tow trucks) to respond quickly to traffic incidents. The storage space is typically provided at the beginning or end of the activity area, or both. An emergency vehicle storage area should not extend into any portion of the buffer space.

D. Termination Area

The termination area is used to return traffic to the normal traffic path. The termination area extends from the downstream end of the activity area to the END ROAD WORK signs, if posted. Conditions may be such that posting of END ROAD WORK signs is not helpful. For example, the signs should normally not be used if other temporary traffic control zones begin within 1 mile (1.6 km) of the end of the work space in rural areas, or about 1/4 mile (400 m) within urban areas.

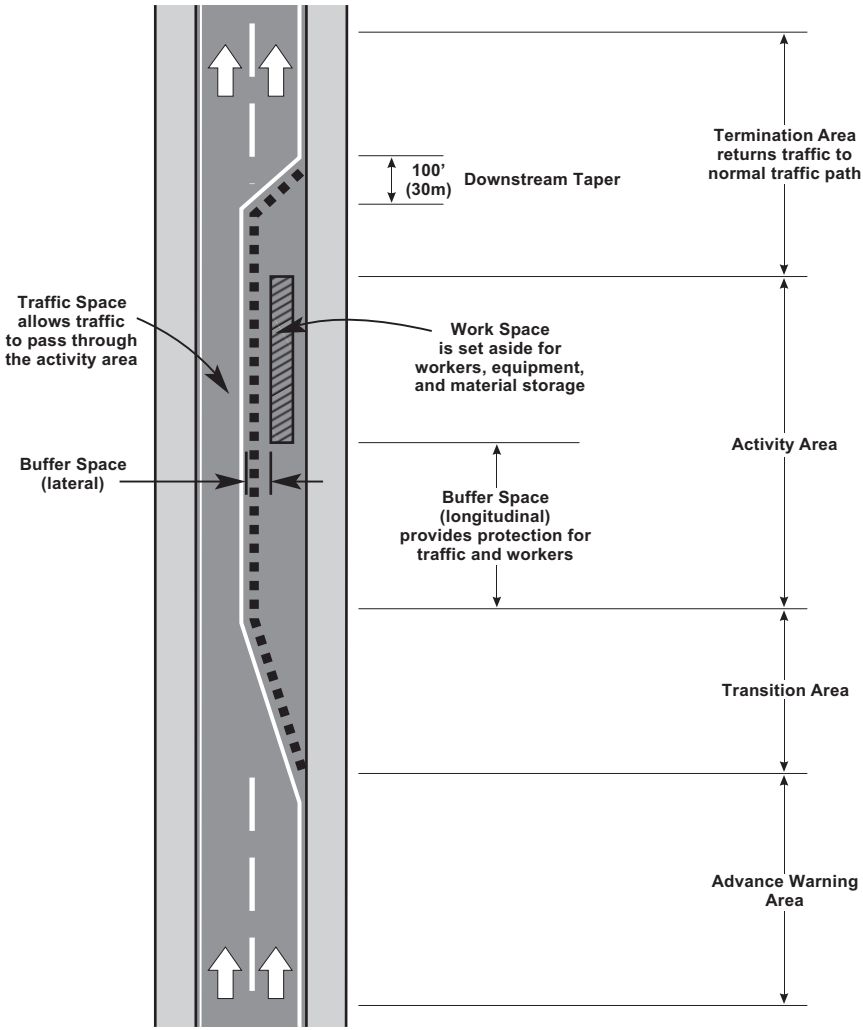


Figure 6-1. Component of a Temporary Traffic Control Zone.

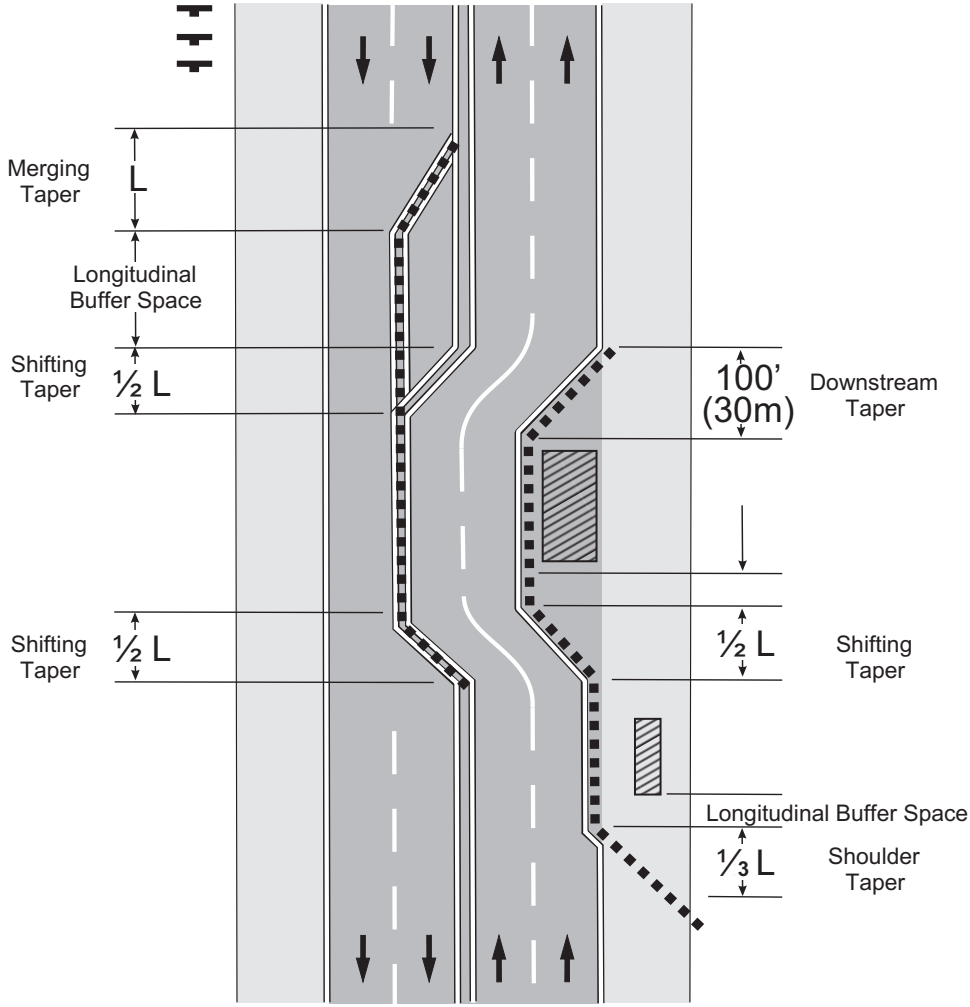


Figure 6-2. Tapers and Buffer Space.

TABLE 6-1

DISTANCE BETWEEN TRAFFIC CONTROL DEVICES "D"

"D" DISTANCES	POSTED SPEED LIMIT, MPH (PRIOR TO WORK AREA)									
	25	30	35	40	45	50	55	60	65	70
D (FEET)	250	300	350	400	450	500	550	600	650	700
D (METERS)	76.2	91.4	106.7	121.9	137.2	152.4	167.6	182.9	198.1	213.4

TABLE 6-2

GUIDELINES FOR LENGTH OF LONGITUDINAL BUFFER SPACE[1] "B"

SPEED* MPH	LENGTH FEET	LENGTH METERS
20	33	10
25	50	15
30	83	25
35	132	40
40	181	55
45	230	70
50	279	85
55	329	100
60	411	125
65	476	145
70	542	165

* POSTED SPEED, OFF PEAK 85TH PERCENTILE SPEED PRIOR TO WORK STARTING, OR THE ANTICIPATED OPERATING SPEED

1 BASED UPON AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) BRAKING DISTANCE PORTION OF STOPPING SIGHT DISTANCE FOR WET AND LEVEL PAVEMENTS (A POLICY ON GEOMETRIC DESIGN OF HIGHWAY AND STREETS), AASHTO. THIS AASHTO DOCUMENT ALSO RECOMMENDS ADJUSTMENTS FOR THE EFFECT OF GRADE ON STOPPING AND VARIATION FOR TRUCKS.

6C-3. TAPERS

A common important element of a temporary traffic control zone is a roadway taper. Tapers may be used in both the transition and termination areas. Tapers are created using a series of channelizing devices or pavement markings placed to move traffic out of or into its normal path. Whenever tapers are to be used near interchange ramps, crossroads, curves, or other influencing factors, it may be necessary to adjust the length of tapers, or extend the lane closure so the taper can be established in advance of these factors. Tapers may need to be shortened (particularly in urban areas characterized by short block lengths, driveways, etc.). Recommended minimum values for types of taper lengths (L) are shown in Table 6-3.

The maximum recommended spacing of channelizing devices in ft (meters) in the taper area should be equal to the posted speed in miles per hour (.3m) and twice the posted speed (.6m) in the parallel area. [**e.g**, a 45 mph posted speed road should normally have devices spaced approximately 45 ft (13.5 m) apart in the taper area and 90 ft (27 m) in the parallel section.]. Types of tapers are shown in Figure 6-1 and the two-way traffic taper is shown in Figure 6-2.

TABLE 6-3

MINIMUM MERGING TAPER LENGTH "L" (FEET)

OFFSET	POSTED SPEED LIMIT, MPH (PRIOR TO WORK AREA)										
FEET	25	30	35	40	45	50	55	60	65	70	TAPER LENGTH "L" IN FEET
1	10	15	20	27	45	50	55	60	65	70	
2	21	30	41	53	90	100	110	120	130	140	
3	31	45	61	80	135	150	165	180	195	210	
4	42	60	82	107	180	200	220	240	260	280	
5	52	75	102	133	225	250	275	300	325	350	
6	63	90	123	160	270	300	330	360	390	420	
7	73	105	143	187	315	350	385	420	455	490	
8	83	120	163	213	360	400	440	480	520	560	
9	94	135	184	240	405	450	495	540	585	630	
10	104	150	204	267	450	500	550	600	650	700	
11	115	165	225	293	495	550	605	660	715	770	
12	125	180	245	320	540	600	660	720	780	840	
13	135	195	266	347	585	650	715	780	845	910	
14	146	210	286	374	630	700	770	840	910	980	
15	157	225	307	400	675	750	825	900	975	1050	

MINIMUM MERGING TAPER LENGTH "L" (METERS)

OFFSET		POSTED SPEED LIMIT, MPH (PRIOR TO WORK AREA)										
METERS	FEET	25	30	35	40	45	50	55	60	65	70	TAPER LENGTH "L" IN METERS
0.3	0.9843	3.1	4.5	6.1	8.0	13.5	15.0	16.5	18.0	19.5	21.0	
0.6	1.9686	6.3	9.0	12.3	16.0	27.0	30.0	33.0	36.0	39.0	42.0	
0.9	2.9529	9.4	13.5	18.4	24.0	40.5	45.0	49.5	54.0	58.5	63.0	
1.2	3.9372	12.5	18.0	24.5	32.0	54.0	60.0	66.0	72.0	78.0	84.0	
1.5	4.9215	15.6	22.5	30.6	40.0	67.5	75.0	82.5	90.0	97.5	105.0	
1.8	5.9058	18.8	27.0	36.8	48.0	81.0	90.0	99.0	108.0	117.0	126.0	
2.1	6.8901	21.9	31.5	42.9	56.0	94.5	105.0	115.5	126.0	136.5	147.0	
2.4	7.8744	25.0	36.0	49.0	64.0	108.0	120.0	132.0	144.0	156.0	168.0	
2.7	8.8587	28.1	40.5	55.1	72.0	121.5	135.0	148.5	162.0	175.5	189.0	
3.0	9.8430	31.3	45.0	61.3	80.0	135.0	150.0	165.0	180.0	195.0	210.0	
3.3	10.8273	34.4	49.5	67.4	88.0	148.5	165.0	181.5	198.0	214.5	231.0	
3.6	11.8116	37.5	54.0	73.5	96.0	162.0	180.0	198.0	216.0	234.0	252.0	
3.9	12.7959	40.6	58.5	79.6	104.0	175.5	195.0	214.5	234.0	253.5	273.0	
4.2	13.7795	43.8	63.0	85.8	112.0	189.0	210.0	231.0	252.0	273.0	294.0	
4.5	14.7638	46.9	67.5	91.9	120.0	202.5	225.0	247.5	270.0	292.5	315.0	

THE FORMULAS FOR THE MINIMUM LENGTH OF A MERGING TAPER IN DERIVING THE "L" VALUES SHOWN IN THE ABOVE TABLES ARE AS FOLLOWS:

"L" = $\frac{W \times S^2}{60}$ WHERE POSTED SPEED PRIOR TO THE WORK AREA IS 40 MPH OR LESS

"L" = S x W WHERE POSTED SPEED PRIOR TO THE WORK AREA IS 45 MPH OR GREATER

L = MINIMUM LENGTH OF MERGING TAPER
S = POSTED SPEED LIMIT IN MPH PRIOR TO WORK AREA
W = WIDTH OF OFFSET

TYPES OF TAPERS

UPSTREAM TAPERS

	TAPER LENGTH
MERGING TAPER	L - MINIMUM
SHIFTING TAPER	1/2 L - MINIMUM
SHOULDER TAPER	1/3 L - MINIMUM
TWO-WAY TRAFFIC TAPER	100' - MAXIMUM
DOWNSTREAM TAPERS (USE IS OPTIONAL)	100' - MINIMUM (PER LANE)

A. Merging Taper

A merging taper requires the longest distances because drivers are required to merge with an adjacent lane of traffic at the prevailing speed. The taper should be long enough to enable merging drivers to adjust their speeds and merge into a single lane before the end of the transition. The values for L in Table 6-3 may be used for this purpose.

B. Shifting Taper

A shifting taper is used when merging is not required, but a lateral shift is needed. Approximately one-half L has been found to be adequate. Where more space is available, it may be beneficial to use longer distances. Guidance for changes in alignment may also be accomplished by using horizontal curves designed for normal highway speeds. One half the values in Table 6-3 may be used for this purpose.

C. Shoulder Taper

A shoulder taper may be beneficial on high-speed roadways with improved shoulders that may be mistaken for driving lanes (when work is occurring in the shoulder area). If used, shoulder tapers approaching the activity area should have a length of about one-third L. If a shoulder is used as a travel lane either through practice or during a temporary traffic activity, a normal merging or shifting taper should be used. Shoulder tapers are not necessary when a vehicle such as a lighted arrow trailer occupies the shoulder at the beginning of the lane closure taper or at the beginning of the longitudinal buffer area of a shoulder only closure. An example of a shoulder taper is presented in Figure 6-3. One-third the values in Table 6-3 may be used for this purpose.

D. Downstream Taper

The downstream taper may be useful in termination areas to provide a visual cue to the driver that access is available to the original lane/path that was closed. When a downstream taper is used, it should have a minimum length of about 100 ft (30 m) per lane, with devices spaced about 16 ft (5 m) apart. An example of a downstream taper is shown in Figure 6-2.

E. One-Lane, Two-Way Taper

The one-lane, two-way traffic taper is used in advance of an activity area that occupies part of a two-way roadway in such a way that a portion of the road is used alternately by traffic in each direction. Typically, traffic is controlled by a temporary traffic signal or a traffic regulator. A short taper having a maximum length of 100 ft (30 m) with channelizing devices at approximately 16 ft (5m) spacing should be used to guide traffic into the one-way section. An example of a one-lane, two-way traffic taper is presented in Figure 6-3.

6C-4 DETOURS AND DIVERSIONS

At detours, traffic is directed onto another roadway to bypass the temporary traffic control zone. Detours should be signed clearly over their entire length so that motorists can easily determine how to return to the original roadway.

At diversions, traffic is directed onto a temporary roadway or alignment placed in or next to the right-of-way, e.g., median crossovers or lane shifts.

6C-5. ONE-LANE, TWO-WAY TRAFFIC CONTROL

Where traffic in both directions must, for a defined distance, use a single lane, appropriate traffic control should be provided for alternate one-way movement through the constricted section. Some means of coordinating movements at each end shall be used to avoid head-on conflicts and to minimize delays. Control points at each end should be chosen to permit easy passing of opposing lines of vehicles. At a "spot" obstruction, however, such as an isolated pavement patch on roadways with low traffic volumes, lower speeds, and adequate sight distance, the movement may be self-regulating, as shown in Figure 6-20.

Alternate one-way traffic control may be accomplished as appropriate by a traffic regulator, (flagger), a pilot car, traffic signals, or by using stop or yield control. This section discusses each of these traffic control techniques.

A. Traffic Regulator Methods

These methods are outlined in Section 6E of this manual, and the current edition of the MDOT Traffic Regulator Instruction Manual.

B. Pilot Car Method

A pilot car is used to guide a queue of vehicles through a normally complex temporary traffic control zone or detour. Its operation must be coordinated with the traffic regulators or other controls at each end of the one-lane section. The pilot car should have the name of the contractor or contracting authority prominently displayed. The PILOT CAR sign (G20-4) shall be mounted at a conspicuous location on the rear of the vehicle.

Two or more pilot cars may be used to guide two-way traffic through a particularly complex detour.

C. Temporary Traffic Signal Method

Traffic signals may be used to control vehicular traffic movements in temporary traffic control zones. Traffic signals should also be considered for half-width bridge reconstruction on low- to moderate-volume highways. Typical applications include highway or street intersections with a temporary haul road or equipment crossing and through areas requiring alternating one-way traffic operations.

D. Stop or Yield Control Method

A yield or stop sign may be installed on low-volume, two-lane roads where one side of the roadway is closed and the other side must serve both directions. The side that is closed should yield to or stop for on-coming traffic on the side that is open. The approach to the side that is not closed shall be visible (for a distance equal to the safe-passing sight distance for that approach) to the driver who must yield or stop. See Section 3B-5, Warrants for No-Passing Zones at Curves.

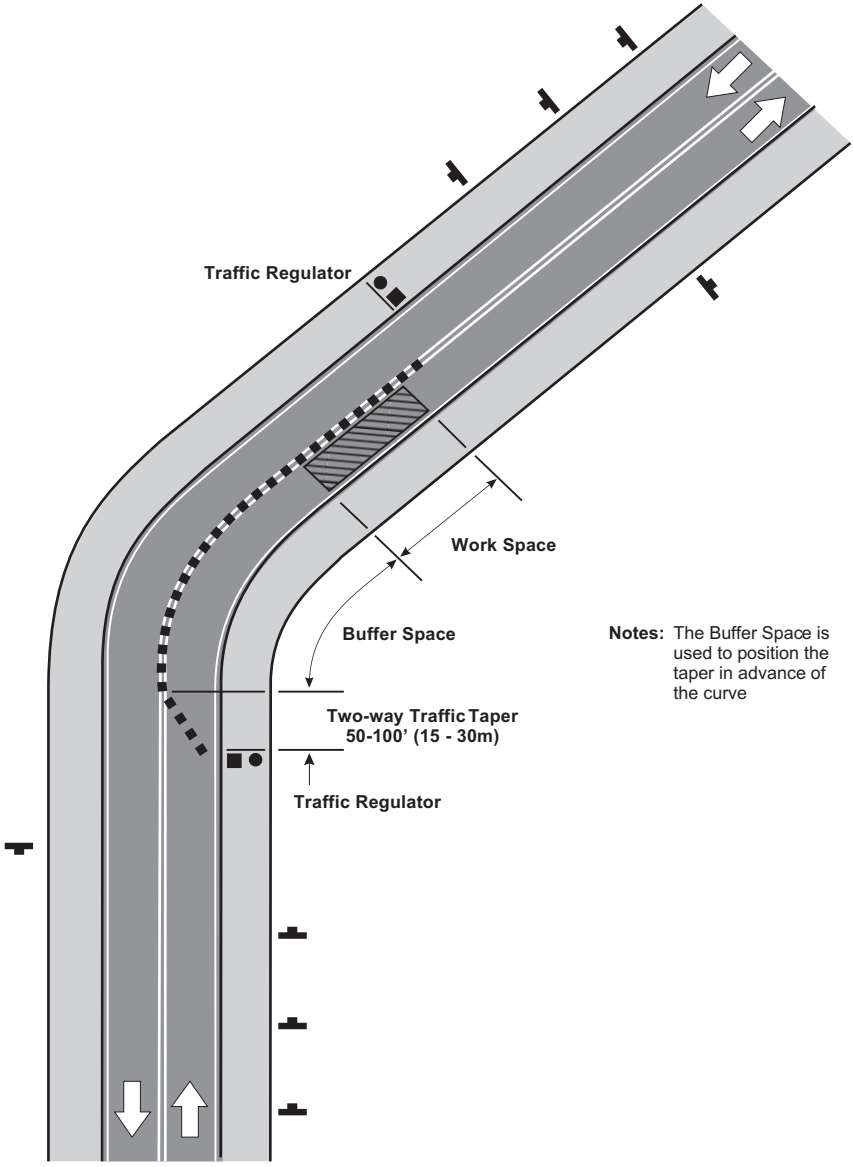


Figure 6-3. Example of One-Lane, Two-Way Traffic Control.

Note: The lane closure has been extended in advance of the curve to provide for adequate sight distance to the traffic regulator.

6C-6 TRANSIT CONSIDERATIONS

Provision for effective continuity of transit service needs to be incorporated into the temporary traffic control planning process. Frequently, public transit buses cannot efficiently be detoured in the same manner as other vehicles (particularly for short-term maintenance projects). On transit routes, the TCP shall provide for features such as temporary bus stops, pull-outs, and waiting areas for transit patrons.

6D. PEDESTRIAN AND WORKER SAFETY

6D-1. PEDESTRIAN SAFETY CONSIDERATIONS

There are three considerations in planning for pedestrian safety in temporary traffic control zones on highways and streets:

- Pedestrians should not be led into direct conflicts with work site vehicles, equipment, or operations.
- Pedestrians should not be led into direct conflicts with mainline traffic moving through or around the work site.
- Pedestrians should be provided with a safe, convenient travel path that replicates as nearly as possible the most desirable characteristics of sidewalks or footpaths.

In accommodating the needs of pedestrians at a work site, it should always be remembered that the range of pedestrians that can be expected is very wide, including the blind, the hearing impaired, and those with walking handicaps. All pedestrians need protection and a smooth, clearly delineated travel path.

Therefore, every effort should be made to separate pedestrian movement from both work site activity and adjacent traffic. Whenever possible, signing should be used to direct pedestrians to safe street crossings in advance of an encounter with a temporary traffic control zone. Signs should be placed at intersections so that pedestrians, particularly in high-traffic-volume urban and suburban areas, are not confronted with mid-block work sites that will induce them to skirt the temporary traffic control zone or make a mid-block crossing. It must be recognized that pedestrians will not retrace their steps to make a safe crossing. Consequently, ample advance notification of sidewalk closures is critically important.

Refer to figures 6-34 and 6-35 for typical traffic control device usage and techniques for pedestrian movements through work areas.

When pedestrian movement through or around a work site is necessary, the aim of the engineer should be to provide a separate, safe footpath without abrupt changes in grade or terrain. Judicious use of special warning and control devices may be helpful for certain difficult work area situations. These include rumble strips, changeable message signs, flashing warning beacons, flags, and warning lights. Traffic regulator activated audible warning devices may be used to alert pedestrians of the approach of erratic vehicles. Also, whenever it is feasible, closing off the work site from pedestrian intrusions is preferable to channelizing pedestrian traffic along the site solely with temporary traffic control devices such as cones, tubular markers, barricades, or drums. If the possibility of vehicle impact is very low, chain link or other suitable fencing, placed well away from traffic, is acceptable. Solid fencing with plywood, however, can create sight distance restrictions at intersections and at work site access cuts. Care must be taken not to create fenced areas that are vulnerable to splintering or fragmentation by vehicle impacts. Similarly, temporary traffic control devices used to delineate a temporary traffic control zone pedestrian walkway must be lightweight and, when struck, present a minimum threat to pedestrians, workers, and impacting vehicles. Only minimally necessary ballasting with safe, lightweight materials should be used with these devices.

Movement by work vehicles and equipment across designated pedestrian paths should be minimized and, when necessary, should be controlled by traffic regulators or temporary traffic control. Excavations across pedestrian walkways should be kept to a minimum, because they often create unacceptable changes in grade and rough or muddy terrain. Pedestrians cannot be expected to traverse these areas willingly. They will tend to avoid these areas by attempting non-intersection crossings

At work sites where falling debris is a concern (such as work on overhead structures), a canopied walkway is frequently needed to protect pedestrians from falling debris. These covered walkways should be sturdily constructed and adequately lit for nighttime use.

In places where pedestrians are judged especially vulnerable to impact by errant vehicles, all foot traffic should be separated and protected by longitudinal barrier systems. Where a barrier is clearly needed, it should have sufficient strength and low deflection characteristics, to keep vehicles from intruding into the pedestrian space. Further, short, noncontinuous segments of longitudinal systems, such as concrete barriers, must be avoided because they nullify the containment and redirective capabilities of the design, increase the potential for serious injury to both vehicle occupants and pedestrians, and encourage the presence of blunt, leading ends. All upstream leading ends that are present shall be appropriately flared or protected with properly installed and maintained impact attenuators. With regard to concrete barriers in particular, it is very important to ensure that adjacent segments are properly joined to effect the overall strength required for the system to perform properly.

It has been determined through study and experience that vertical curbs cannot prevent vehicle intrusions onto sidewalks. As a consequence, normal vertical curbing is not a satisfactory substitute for positive barriers when these are clearly needed. Similarly, contractor-constructed wooden railings, chain-link fencing with horizontal pipe runs, and similar systems placed directly adjacent to vehicle traffic are not acceptable substitutes for crash worthy positive barriers. In many instances, temporary positive barriers may be necessary to prevent pedestrians from unauthorized movements into the active work area and to prevent conflicts with traffic by eliminating the possibility of mid-block crossings.

If a high potential exists for vehicle incursions into the pedestrian space, judgment must be exercised as to whether to reroute pedestrians or use barriers. Normally, standard traffic control devices can satisfactorily delineate a temporary traffic control zone pedestrian path, but fail-safe channelization can never be guaranteed with these devices because of the gaps between them. Tape, rope, or plastic chain strung between devices can help discourage pedestrian movements off the designated pathway. Good engineering judgment in each temporary traffic control zone situation should determine the extent of pedestrian needs. Traffic Control Plans (TCPs) for temporary traffic control should provide both a sense of security and safety for pedestrians walking past work sites and consistent, unambiguous channelization to maintain foot traffic along the desired travel paths.

6D-2. WORKER SAFETY CONSIDERATIONS

Of equal importance to the safety of the public traveling through the temporary traffic control zone is the safety of the worker performing the many varied tasks within the work site. Work areas present temporary and constantly changing conditions that are unexpected by the traveler. Further, these work conditions almost always present situations that are more confusing for the driver. This creates an even higher degree of vulnerability for the personnel on or near the roadway.

Following the Fundamental Principles noted above in Section 6B will usually provide the degree of control and traffic operation that will bring about safe conditions for the worker. Of particular importance is maintaining work areas with traffic flow inhibited as little as possible, providing standard and clear traffic control devices that get the driver's attention and provide positive direction.

Below are key elements of traffic control management that should be considered in any procedure for assuring worker safety:

A. Training

All workers should be trained in how to work next to traffic in a way that minimizes their vulnerability. In addition, workers with specific traffic control responsibilities should be trained in traffic control techniques, device usage, and placement.

B. Worker Clothing

Workers exposed to traffic should be attired in bright, highly visible clothing.

C. Barriers

Barriers should be placed along the work space depending on such factors as lateral clearance of workers from adjacent traffic, speed of traffic, duration of operations, time of day, and volume of traffic.

D. Speed Reduction

In highly vulnerable situations, consideration should be given to reducing the speed of traffic through regulatory speed zoning, funneling, use of police, lane reduction, or traffic regulators.

E. Use of Police

In highly vulnerable work situations, particularly those of relatively short duration, stationing police units heightens the awareness of passing traffic and will likely cause a reduction in travel speed.

F. Lighting

For nighttime work, lighting the work area and approaches may allow the driver better comprehension of the requirements being imposed. Care should be taken to ensure that the lighting does not cause blinding of the driver.

G. Special Devices

Judicious use of special warning and control devices may be helpful for certain difficult work area situations. These include rumble strips, changeable message signs, flashing identification beacons, flags, and warning lights. Traffic regulator activated audible warning devices may be used to alert workers to the approach of erratic vehicles. Misuse and overuse of special devices/techniques can greatly lessen their effectiveness.

H. Public Information

Improved driver performance may be realized through a well-prepared and complete public relations effort that covers the nature of the work, the time and duration of its execution, its anticipated effects upon traffic and possible alternate routes and modes of travel. Such programs have been found to result in a significant drop in traffic; that reduces the possible number of conflicts and may allow a temporary lane closing for additional buffer space.

I. Road Closure

If alternate routes are available to handle detoured traffic, the road may be closed temporarily. In addition to offering maximum worker safety, the DETOUR may facilitate quicker project completion and thus further reduce worker vulnerability.

Like other provisions of work area safety set forth in this part of the MMUTCD, the various traffic control techniques must be applied by qualified persons after appropriate engineering studies and with sound engineering judgment and common sense.

6E. TRAFFIC REGULATORS

6E-1. FUNCTION

The primary function of traffic control procedures for traffic regulators, formerly known as flaggers, is to move vehicles and pedestrians safely and expeditiously through or around temporary traffic control zones while protecting on-site workers and equipment.

Additional information and a detailed outline of the traffic regulator procedures and conduct is contained in the Michigan Department of Transportation "Traffic Regulators Instruction Manual"

6E-2. QUALIFICATIONS FOR TRAFFIC REGULATORS

Because traffic regulators are responsible for public safety and make the greatest number of public contacts of all highway workers, they should have the following minimum qualifications:

A. Sense of responsibility for the safety of the public and workers

B. Training in safe traffic control practices

C. Average intelligence

D. Good physical condition, including sight and hearing

E. Mental alertness and the ability to react in an emergency

F. Courteous but firm manner

G. Neat appearance

6E-3. HIGH-VISIBILITY CLOTHING

The traffic regulator's upper body garment shall be either fluorescent orange, yellow, strong yellow green or a combination of these colors, and shall contain retro-reflective material which shall be either orange, yellow, white, silver, or strong yellow green. The retro-reflective clothing shall be designed to be visible at 360 degrees through the full range of body motions, day and night. This is a requirement of Part 22 of the Construction Safety Standards of the Michigan Occupational Health and Safety Act, PA 154 of 1974.

Uniformed law enforcement officers may be used as traffic regulators in some locations, such as an urban intersection, where enforcement of traffic movements is important. Uniformed law enforcement officers may also be used on freeways where traffic is channeled around work site and it is necessary to assure that advisory and regulatory speeds are being enforced. For nighttime work and in low-visibility situations, a retro-reflective garment as described above should be worn.

6E-4. HAND-HELD (PADDLE) SIGN

The pole-mounted paddle sign is illustrated in Figure 6-4.

Where it is necessary to employ the services of a traffic regulator, a hand-held (paddle) sign shall be used to control traffic. The hand-held (paddle) sign shall have two faces and be positioned at the top of a staff in such a manner that the bottom of the sign is as least 6 ft (1.8 meters) above the roadway surface. The sign shall be at least 18" x 18"(450 mm x 450 mm) and the letters shall have a minimum height of 6" (150 mm.) One side of the sign shall display a STOP face and the other side shall display the message SLOW, except for haul road traffic regulating, and where it is necessary for one traffic regulator to stop two directions of traffic at the same time. In the latter case, a STOP face shall be used on each side of the sign.

The STOP face shall have a red background with white letters and border. The SLOW face shall have an orange background with black letters. The sign shall be octagonal-shaped in design, and the portions falling outside diamond-shaped SLOW face should be black. When the sign paddle is used during the hours of darkness, the red and white of the STOP face and the orange of the SLOW face shall be reflectorized. Sheet metal or other light semi-rigid material may be used for mounting the STOP and SLOW faces.

Lights approved by the appropriate highway authority and reflectorized sign paddles shall be used to regulate traffic at night. Daytime procedures shall be followed whenever such lights and paddles are used at night.

To improve conspicuity, the pole sign may be supplemented by one or two symmetrically positioned alternately flashing white high-intensity lights on either side of or above and below the STOP legend. The lights may be activated by a switch on the pole on demand. The pole mounted sign shall be reflectorized.

A mechanical flagger shall not be used as a substitute for a traffic regulator nor as a supplemental traffic control device.

6E-5. HAND-SIGNALIZING PROCEDURES

When hand signaling is necessary to supplement the pole mounted sign, the following methods shall be used:

A. To Stop Traffic

The traffic regulator shall face traffic and show the STOP face of the sign toward traffic in a stationary position with the free arm extended horizontally away from the body towards the traffic. The free arm should be raised with the palm toward approaching traffic.

B. Direct Stopped Traffic to Proceed

The traffic regulator shall face traffic with the SLOW sign face held in a stationary position with the arm extended horizontally away from the body. The traffic regulator should motion with the free hand for traffic to proceed.

C. Alert or Slow Traffic

The traffic regulator shall face traffic with the SLOW face of the pole mounted sign held in a stationary position with the arm extended horizontally away from the body. The traffic regulator may motion up and down with the free hand, palm down, indicating that the vehicle should slow down.

6E-6 FLAG SIGNALING PROCEDURES

The following methods of signaling with a flag should be used:

A. To Stop Traffic—The traffic regulator shall face traffic and extend the flag staff horizontally across the traffic lane in a stationary position, so that the full area of the flag is visible hanging below the staff. The free arm should be raised with the palm toward approaching traffic.

B. To Direct Stopped Traffic to Proceed—The traffic regulator shall face traffic with the flag and arm lowered from view of the driver. With the free hand, the flagger should motion traffic to proceed. Flags shall not be used to indicate traffic may proceed.

C. To Alert or Slow Traffic—The traffic regulator shall face traffic and slowly wave the flag in a sweeping motion of the extended arm from shoulder level to straight down, without raising the arm above a horizontal position.

Flag use shall be limited to emergency situations. Flags used for signaling shall be a minimum of 2 ft. (600 mm) square, made of a good grade of red material, and securely fastened to a staff about 3 ft. (900 mm) long. The free edge should be weighted so the flag will hang vertically, even in heavy winds. During night operations, flags shall be retro-reflective red and the Michigan Occupational Health and Safety Act, P A 154 of 1974 requires the traffic regulator's station to be illuminated with flood lights.

6E-7 TRAFFIC CONTROL STATIONS WITH MORE THAN ONE TRAFFIC REGULATOR

Traffic Regulator stations should be visible far enough ahead to permit all vehicles to stop. Traffic control stations shall be located far enough ahead of the work space so that approaching traffic has sufficient distance to stop before entering the work space. Table 6-2, *Guidelines for Length of Longitudinal Buffer Space* , may be used for locating traffic control stations in advance of the work space. These distances may be adjusted based on speeds, the effect of grades and for trucks.[2] Traffic regulator stations shall be preceded by the proper advance warning sequence of signs. More than one traffic regulator may be required in each direction under some geometric and traffic volume situations. Traffic control stations shall be illuminated when operated at night.

The traffic regulator should establish their position on the shoulder adjacent to the traffic being controlled. A traffic regulator should stand in the lane being used by moving traffic only after traffic has stopped, and the traffic regulator needs to be visible to the traffic or to communicate with drivers. Because of the various roadway geometrics, the traffic regulator should be clearly visible to approaching traffic at all times. For this reason, the traffic regulator should stand alone. Other workers should not be permitted to congregate around the traffic regulator station. The traffic regulator should be stationed far enough ahead of the work force to warn them with horns or whistles of an approaching out-of-control vehicle.

6E-8. TRAFFIC CONTROL STATIONS WITH A SINGLE TRAFFIC REGULATOR

An operation that controls two directions of traffic will generally require two traffic regulators. However, one traffic regulator may be appropriate if the following conditions are met:

A. The work area is short (e.g., repairing a guard rail ending, or minor shoulder repair).

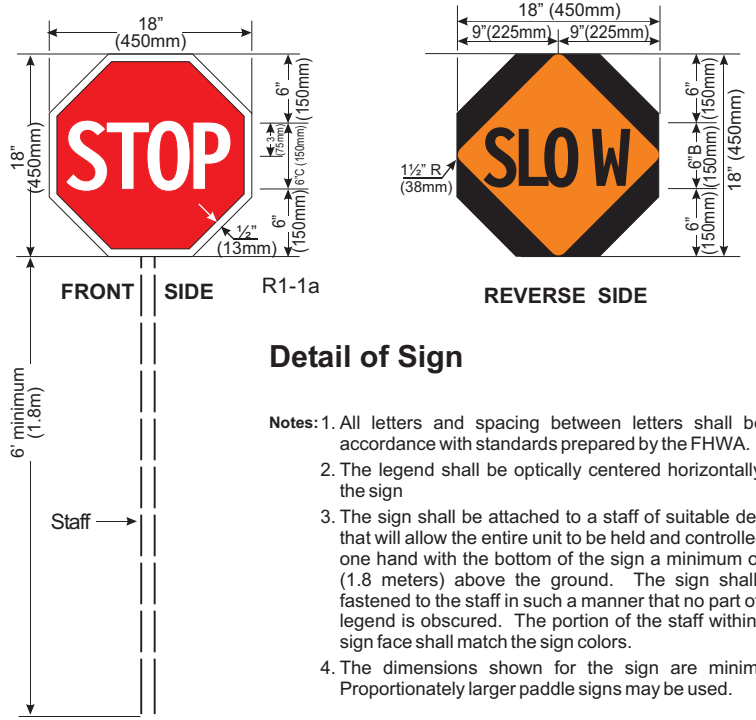
B. The work area is on a straight section of road with good visibility from both approaches.

C. The traffic volumes and speeds are low.

In these cases, the single traffic regulator should operate from the roadway shoulder directly opposite the work area if sufficient space is available. This places the traffic regulator in a position highly visible to the approaching traffic from either direction, and may provide a personal escape route if it becomes necessary. The single traffic regulator may have to move a short distance toward each end of the work zone as he or she stops cars coming into the zone at that end. Motorists in the closed lane should be directed to stop while in their lane well in advance of the work area. Motorists in the open lane should also stop where the traffic from the opposite direction may easily proceed around the work without conflicting with the other stopped traffic.

[2] A Policy on Geometric Design of Highways and Streets, AASHTO.

PADDLE SIGN



Detail of Sign

Notes:

1. All letters and spacing between letters shall be in accordance with standards prepared by the FHWA.
2. The legend shall be optically centered horizontally on the sign
3. The sign shall be attached to a staff of suitable design that will allow the entire unit to be held and controlled by one hand with the bottom of the sign a minimum of six feet (1.8 meters) above the ground. The sign shall be fastened to the staff in such a manner that no part of the legend is obscured. The portion of the staff within the sign face shall match the sign colors.
4. The dimensions shown for the sign are minimum. Proportionately larger paddle signs may be used.

Figure 6-4. Detail of pole mounted STOP/SLOW Paddle Sign.

6F. TYPES OF DEVICES

The design and applications of traffic control devices used in temporary traffic control zones are described in this chapter. A traffic control device is a sign, signal, marking or other device placed on or adjacent to a street or highway (by authority of a public body or official having jurisdiction) to regulate, warn, or guide traffic. Specific crash worthy information on devices described in this chapter can be found in the AASHTO Roadside Design Guide.[5]

6F-1. SIGNS

Permanent signs within the traffic control zone which are still applicable may remain in place. Temporary traffic control zone signs convey both general and specific messages by means of words or symbols and have the same three categories as all traffic signs: Regulatory signs, Warning signs, and Guide signs. Regulatory signs shall follow the standard in Section 2B-3. Temporary warning signs for work zone traffic control shall have a black legend on an orange background. . Colors for guide signs follow the standard in Section 2D-3, except for special information signs as noted below in Section 6F-1C.

Where the color orange is specified, fluorescent red-orange or fluorescent yellow-orange colors may be used. The fluorescent versions of orange provide higher conspicuity than standard orange, especially at twilight.

All signs used at night shall be either retro-reflective, with a material that has a smooth, sealed outer surface, or illuminated to show similar shape and color both day and night. Sign illumination may be either internal or external. Roadway lighting does not meet the requirements for sign illumination. Standard orange flags, Type A low intensity, or Type B high-intensity flashing warning lights may be used in conjunction with signs. However, they must not block the sign legend.

The dimensions of signs shown herein are for standard sizes, which may be increased wherever necessary for greater legibility or emphasis. On secondary highways and city streets, smaller signs may be used if authorized by lawful authority. Deviations from standard sizes as prescribed herein shall be in **6"** (150mm) increments. Sign design details, including recommended substrates, shall be in accordance with those contained in Standard Highway Signs Book.[6]

[5] AASHTO, 44 North Capitol, N.W.,Suite 225, Washington, D.C. 20001

[6] Standard Highway Signs Book, (Michigan's version)

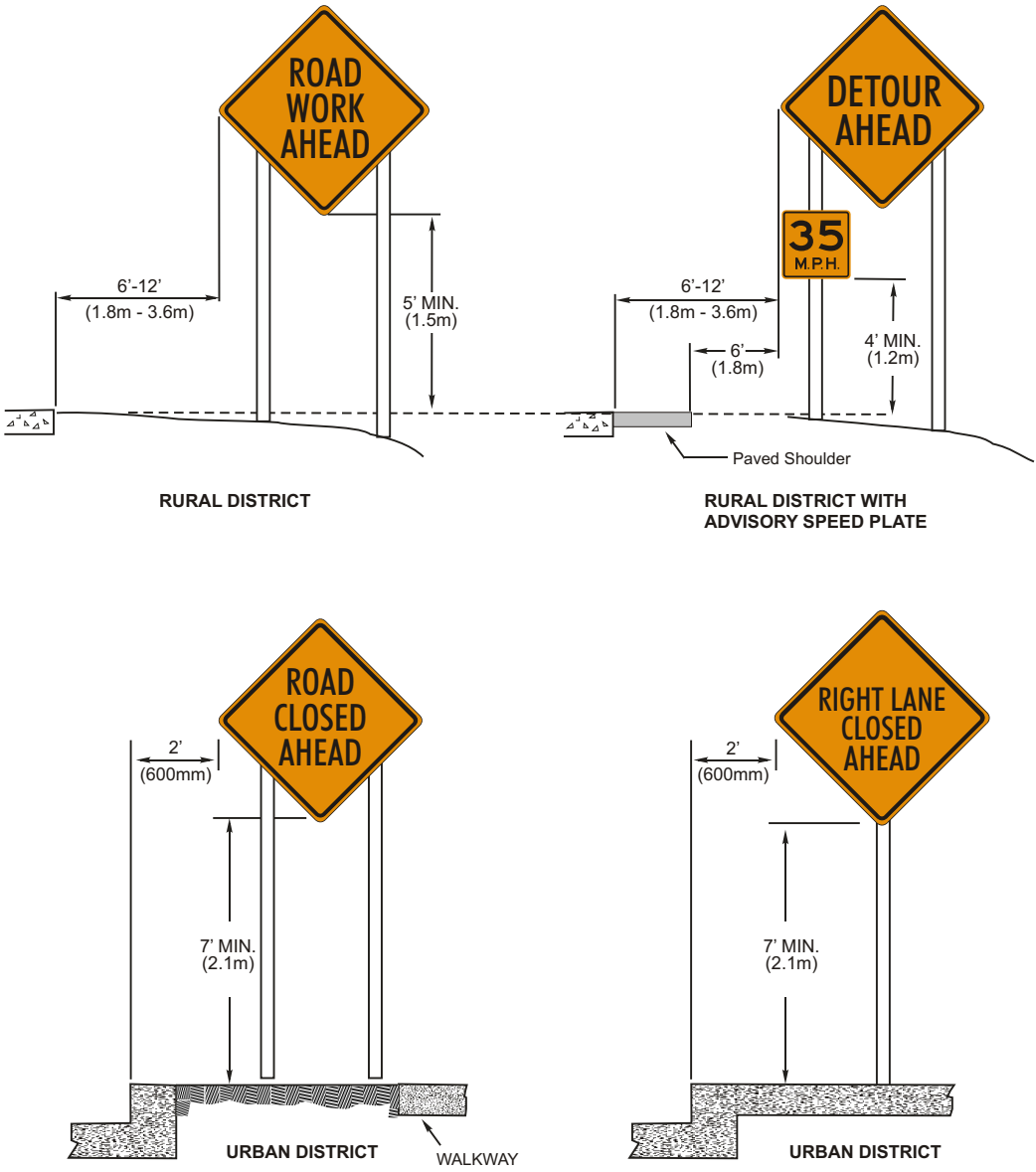


Figure 6-5. Height and Lateral Locations of Signs -- Typical Installations.

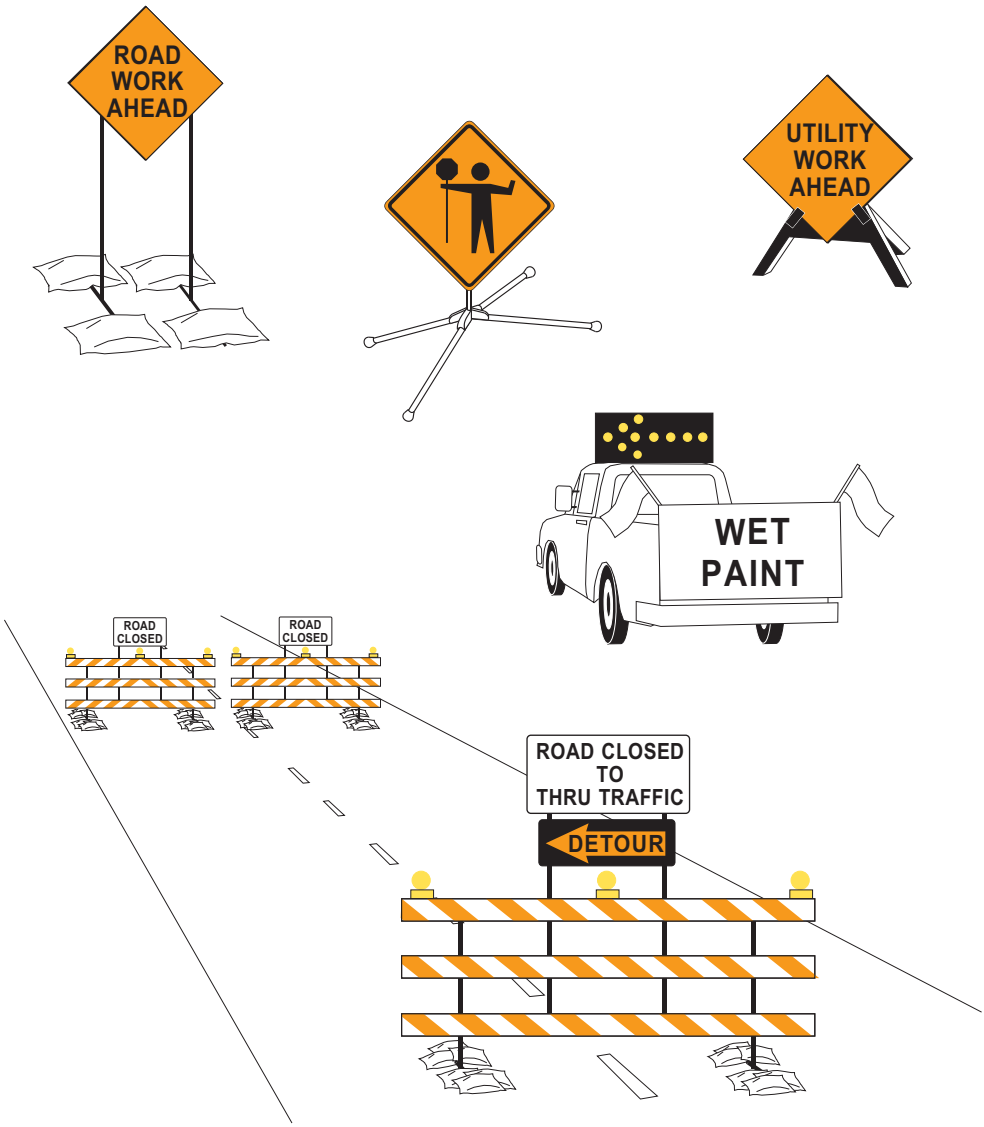


Figure 6-6. Methods of Mounting Signs Other Than on Posts.

As a general rule, signs should be located on the right-hand side of the roadway. When special emphasis is needed, signs may be placed on both the left and right sides of the roadway. Signs may be mounted on portable supports placed within the roadway itself. Signs, although ordinarily mounted on posts, may also be mounted on or above barricades.

Guidelines for height and lateral clearance of temporary post-mounted roadside signs are shown in Figure 6-5. Signs erected at the side of the road should be mounted at a height of at least 5 ft (1.5 m), measured from the bottom of the sign to the near edge of the pavement. The height to the bottom of a secondary sign mounted below another sign may be 1 ft (300 mm) less than the appropriate height specified above.

Methods of mounting signs other than on posts are illustrated in Figure 6-6. Signs may be mounted on portable supports for short-term, short-duration, and mobile conditions(see Section 6G-2).Unprotected sign systems should be crashworthy (refer to National Cooperative Highway Research Program (NCHRP), Report 350, for additional guidance).[6] Signs mounted on Type III barricades should not cover more than 50 percent of the top two rails or 33 percent of the total area of the three rails. The bottom of signs mounted on TYPE III barricades or temporary supports shall be no less than 1 ft (300 mm) above the traveled way.

For mobility of maintenance operations a large sign may be mounted on a maintenance vehicle (either the work vehicle or the protection vehicle) stationed in advance of the work area or moving along with it. As an alternative, a mobile sign display may be mounted on a trailer.

Signs used in temporary traffic control zones are moved frequently, loaded and unloaded from trucks, and in general receive much harsher treatment than permanent signs. For this reason, particular attention must be given to maintaining signs properly for cleanliness, visibility, and correct positioning. Signs that are excessively worn, scratched, bent, or have lost a significant amount of retro-reflectivity should be promptly replaced.

A. Regulatory Signs

1. Authority

Regulatory signs inform highway users of traffic laws or regulations and indicate the applicability of legal requirements that would not otherwise be apparent. Because regulatory signs impose legal obligations on all drivers, they shall be authorized by the public body or official having jurisdiction and shall conform to Section 2B of this manual.

[6] **NCHRP, Transportation Research Board, 2101 Constitution Avenue, NW , Washington, D.C. 20418**

2. Design

Regulatory signs are generally rectangular, with a black legend and border on a white background. Exceptions include the STOP sign, the YIELD sign, the DO NOT ENTER sign, the WRONG WAY sign, and the one-way arrow sign. The one-way arrow sign may be either a horizontal or vertical rectangular plate. Regulatory signs are illustrated in Figure 6-7. Design details for all regulatory signs are given in Part 2 of the MMUTCD and in the Standard Highway Signs Book.[7]

3. Application

If temporary traffic control zones require regulatory measures different from those normally in effect, the existing permanent regulatory devices shall be temporarily removed or covered and superseded by the appropriate temporary regulatory signs and shall follow applicable ordinances or statutes of the jurisdiction, as well as comply with the sign design standards of the MMUTCD.

[7] Standard Highway Signs, (Michigan's version)

R1-1
36″ x 36″
900mm x 900mm

R1-2
36" x 36" x 36"
900mm x 900mm x900mm

R2-1
48″ x 60″
1200mm x 1500mm

R2-5a
48″ x 60″
1200mm x 1500mm

R2-5b
48″ x 60″
1200mm x 1500mm

R2-5c
48″ x 60″
1200mm x 1500mm

R3-1
24" x 24"
600mm x 600mm

R3-3
24" x 24"
600mm x 600mm

R3-4
24" x 24"
600mm x 600mm

R3-5l
30" x 36"
750mm x 900mm

R3-6
30" x 36"
750mm x 900mm

R3-8
30" x 30"
750mm x 750mm

R4-1
48″ x 60″
1200mm x 1500mm

R4-2
48″ x 60″
1200mm x 1500mm

R4-7
24" x 30"
600mm x 750mm

R5-1
30" x 30"
750mm x 750mm

R6-2
18" x 24"
450mm x 600mm

R8-3a
24" x 24"
600mm x 600mm

R6-1
36" x 12"
900mm x 300mm

Figure 6-7 Commonly Used Regulatory Signs.

4. ROAD (STREET) CLOSED Sign (R11-2)

The ROAD (STREET) CLOSED sign may be used where the roadway is closed to all traffic except contractors' equipment or officially authorized vehicles and may be accompanied by appropriate detour signing. The sign should be erected at or near the center of the roadway on or above a Type III barricade that closes the roadway (Section 6F-5F). The sign should have a minimum size of 48" x 30" (1200 mm x 750 mm). The words BRIDGE CLOSED may be substituted for ROAD CLOSED, where applicable. The ROAD (STREET) CLOSED sign shall not be used where traffic is maintained or where the actual closing is some distance beyond the sign.

R11-2
48" x 30"
1200mm x 750mm

R11-3
60" x 30"
1500mm x 750mm

R11-4
60" x 30"
1500mm x 750mm

5. LOCAL TRAFFIC ONLY Signs (R11-3, R11-4)

The LOCAL TRAFFIC ONLY signs should be used where through traffic must detour to avoid a closing of the road or street some distance beyond the sign, but where the road or street is open for local traffic up to the point of closure. The sign shall carry the legend ROAD CLOSED (XX) MILES OR FEET AHEAD—LOCAL TRAFFIC ONLY or, optionally, STREET CLOSED TO THRU TRAFFIC, and should be accompanied by appropriate warning and detour signing as illustrated in Figure 6-12. The Michigan State Law, as contained in the Michigan Vehicle Code (Section 247.292), requires appropriate detour signing during closure. The words BRIDGE OUT or BRIDGE CLOSED may be substituted for ROAD CLOSED where applicable.

6. WEIGHT LIMIT Signs (R12-1, R12-2, R12-5)

For traffic safety in areas of road or street construction and maintenance, a WEIGHT LIMIT sign may show the gross weight or axle weight that can be permitted on the roadway surface or bridge. Weight restrictions should be consistent with State or local regulations and shall not be imposed without the approval of the authority having jurisdiction over the highway. When weight restrictions are imposed, a marked detour should be provided for vehicles weighing more than the limit posted.

R12-1
24" x 30"
600mm x 750mm

R12-2
24" x 30"
600mm x 750mm

R12-5
30" x 36"
750mm x 900mm

7. TEMPORARY WORK ZONE SPEED LIMIT Signs (R2-1, R2-5)

The TEMPORARY SPEED LIMIT signing shall display the limit established by the provisions of Section 627, paragraph 9 and Section 628, paragraph 3 of the Michigan Vehicle Code, as amended. This statute provides for a statutory maximum of 45 mph (70km/h), unless otherwise determined and posted where construction, maintenance, surveys, utility work or other activity which requires all or part of one or more traffic lanes be closed to perform the work.

8. TRAFFIC FINES DOUBLED IN WORK ZONES Signs (R5-18)

In accordance with the Michigan Vehicle Code, Section 257.601b, paragraph 2, The regulatory signs TRAFFIC FINES DOUBLED IN WORK ZONES (R5-18, R5-18a) are required. The signs shall conform to the requirements of color, shape, and alphabet size and series.

9. Other Special Regulatory Signs

Special word message regulatory signs may be needed based on an engineering analysis. The sign should conform to the requirements of color, shape, and alphabet size and series. The sign message should be brief, legible, and clear.

B. Warning Signs

1. Function

Temporary traffic control zone warning signs notify drivers of general or specific conditions on or adjacent to a roadway.

2. Design and Application

With some exceptions, warning signs shall be diamond-shaped with a black symbol or message on an orange background. Warning signs developed exclusively and used for incident management shall have an orange background. However, in emergencies, available signs having yellow backgrounds may be used if orange signs are not readily available.

Warning signs may be used singly or in combination. Because of their importance, they shall have a standard size of 48" (1200 mm) square and shall be the standard diamond shape for warning signs, except in emergencies cited. Signs larger than 48" (1200 mm) square may be used for additional emphasis of the temporary traffic control zone. Where speeds and volumes are moderately low, a minimum size of 36" (900 mm) square may be used for advance warning signs, if they have a minimum letter size of 5" (125 mm). On secondary roads or city streets where speeds are very low, signs smaller than the standard size, but not less than 24"(600 mm) square, may be used for warning signs having short word messages or clearly understood symbols.

Where distances are not shown on warning signs as part of the message, a separate panel with the distance legend may be mounted immediately below the sign on the same support.

3. Spacing of Warning Signs -These are covered in Sections 6C-2 (Table 6-1), 6H-3 Typical Application Diagrams and the following Table 6-1.

Warning signs should be placed at varying distances in advance of the work area, depending on the roadway type, condition, and speed. Where a series of advance warning signs is used, the warning sign nearest the point of restriction should be placed approximately 250 ft (75 m) away for low-speed urban streets and up to 700 ft (210 m) away or more for expressways and freeways.

TABLE 6-1 Advance Sign Spacing Distances "D"

SPEED MPH	DISTANCE Ft	(m)
25	250	(76.2)
30	300	(91.4)
35	350	(106.7)
40	400	(121.9)
45	450	(137.2)
50	500	(152.4)
55	550	(167.6)
60	600	(182.9)
65	650	(198.1)
70	700	(213.4)

A method to determine adequate spacing is to use the formula D = S x 10 (Metric D = S x 3) Where D = the distance between signs in Feet (meters) and S = the posted speed in mph.

4. Other Approach Warning Signs

Certain conditions require other advance warning signs, such as a signal ahead or because an obstruction may require a motorist to stop. There are no specified standards for such signs. The determination of the sign or signs to be used shall be based on an engineering study using the following sections *(5-24)* as guidelines. As an alternative to a specific distance on these advance warning signs, the word AHEAD may be used.

5. Application of Warning Signs for Maintenance, Minor Road Work, and Utility Sites

At many maintenance, minor road work, and utility sites, particularly on lightly traveled roads, the sequence of advance warning signs prescribed for major road work may not be needed. The signs described in the following sections will usually provide sufficient advance warning in such situations, either by themselves or with other advance warning signs.

W21-4a
48" x 48"
1200mm x 1200mm

W21-4
48" x48"
1200mm x 1200mm

6. ADVANCE ROAD/STREET WORK Sign (W20-1 W21-4 & W21-4a)

The Advance (Road/Street) Construction sign is to be located in advance of the initial activity or detour a driver may encounter, and is intended for use as a general warning of obstructions or restrictions. It carries the legend ROAD (STREET) WORK AHEAD. It may be used with the CONSTRUCTION legend; however, WORK legend is preferred. A distance legend in place of AHEAD is also acceptable.

7. DETOUR Sign (W20-2)

The DETOUR sign is used in advance of a detour that directs traffic onto another highway in order to bypass the work zone. It carries the legend DETOUR AHEAD A distance legend in place of AHEAD is also acceptable

W20-2
48" x 48"
1200mm x 1200mm

W20-3
48" x 48"
1200mm x 1200mm

W20-4
48" x 48"
1200mm x 1200mm

8. ROAD (STREET) CLOSED Sign (W20-3)

The ROAD (STREET) CLOSED sign is used ahead of that point where a highway is closed to all traffic or to all but local traffic. It carries the legend ROAD (STREET) CLOSED AHEAD. A distance legend in place of AHEAD is also acceptable.

9. ONE LANE ROAD Sign (W20-4)

The ONE LANE ROAD sign should be used ahead of that point where traffic in both directions must use a common single lane. It carries the legend ONE LANE ROAD 1,000 FT or ONE LANE ROAD AHEAD. The sign may be used in conjunction with appropriate legends or with other warning signs.

If the affected one-lane roadway is not visible from one end to the other, or if the traffic is such that simultaneous arrivals at both ends occur frequently, traffic regulator procedures or signal control should be used to control alternate traffic flows.

10. RIGHT/LEFT LANE CLOSED Sign (W20-5)

The LANE CLOSED sign is used in advance of that point where one lane of a multiple-lane roadway is closed.

It carries the legend RIGHT (LEFT) LANE CLOSED (XX) FEET or RIGHT (LEFT) LANE CLOSED AHEAD. The sign may be used in conjunction with appropriate legends or with other warning signs.

W20-5
48" x 48"
1200mm X1200mm

W4-2R
48″ x 48″
1200mm x 1200mm

W6-3
48″ x 48″
1200mm x 1200mm

11. TWO RIGHT/LEFT LANES CLOSED AHEAD/XX FT (W20-5)

The TWO RIGHT/LEFT LANES CLOSED sign should be used in advance of the point where the first lane closure occurs. The legend may contain the advance distance or use the legend AHEAD.

12. LANE REDUCTION SYMBOL Sign (W4-2, R OR L)

The lane reduction sign is intended for use in advance of a lane closure on a multi-lane facility. It may be used alone or supplementing the W20-5, R or L sign

13. TWO-WAY TRAFFIC Sign (W6-3)

The TWO-WAY TRAFFIC symbol sign should be used as needed at intervals to periodically remind drivers that they are on a two-way highway with opposing traffic.

W20-7a
48" x 48"
1200mm x 1200mm

W20-15
48" x 48"
1200mm x 1200mm

W20-4a
48" x 48"
1200mm x 1200mm

14.____Traffic Regulator Symbol Sign (W20-7a)

The Traffic Regulator symbol sign (W20-7a) should be used before any point where a traffic regulator is stationed to control traffic. A distance legend may be displayed on a supplemental plate below the symbol sign. The sign shall be used in conjunction with appropriate legends or with other warning signs, such as the BE PREPARED TO STOP (W20-15).

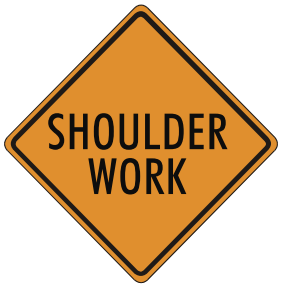
The Traffic Regulator word message sign (W20-7) with distance legends may be substituted for the traffic regulator symbol sign (W20-7a).

The Traffic Regulator sign shall be removed, covered, or turned to face away from traffic when the traffic regulator is not at the station.

15. Advance YIELD TO ONCOMING TRAFFIC Sign (W20-4a)

The YIELD TO ONCOMING TRAFFIC Sign is intended for use in advance of a point where traffic in both directions must use a single lane and there are no traffic regulators to control traffic through the construction area. It should be used in conjunction with the One Lane Road Ahead sign (W20-4) and shall face only the flow of traffic whose lane is closed. The alternate legend WATCH FOR ONCOMING TRAFFIC sign (W20-4b) may be used to alert drivers in the open lane that oncoming traffic may be encountered. The sign shall not be used when there is either a traffic regulator or traffic signals in use (See Figure 6-19)

W21-5
48" x 48"
1200mm x 1200mm



W21-5
48" x 48"
1200mm x 1200mm

W21-6
48" x 48"
1200mm x 1200mm

W8-9b
48" x 48"
1200mm x 1200mm

16. LOOSE STONE/GRAVEL Sign (W8-7)

The LOOSE STONE OR GRAVEL sign is intended for use to warn drivers of the pavement surface condition during seal coat type paving projects.

17. SHOULDER WORK Sign (W21-5)

The SHOULDER WORK sign may be used to warn of maintenance, reconstruction, or utility operations on the shoulder, where the traveled way is unobstructed.

18. SURVEY CREW Sign (W21-6)

The SURVEY CREW sign may be used to warn of survey crews working in or next to the roadway.

19. Signs for Blasting Areas

Radio frequency (RF) energy can cause the premature firing of electric detonators (blasting caps) used in temporary traffic control zones or blasting zones. Drivers must be warned to turn off mobile radio transmitters and cellular telephones. The Institute of Makers of Explosives publishes information on this hazard and guidelines for safe operations.[9]

A sequence of signs should be used to direct operators of mobile radio equipment to turn off transmitters in a blasting area. A minimum safe distance of 1000 ft (300 m) should be used for warning sign placement. These signs shall be prominently displayed and covered or removed when there are no explosives in the area or the area is otherwise secured.

20. BLASTING ZONE Sign (W22-1)

The BLASTING ZONE AHEAD sign should be used in advance of any work where explosives are being used. The TURN OFF 2-WAY RADIOS AND CELLULAR TELEPHONES and END BLASTING ZONE signs shall be used in sequence with this sign.

The TURN OFF 2-WAY RADIO AND CELLULAR TELEPHONES sign should follow the BLASTING ZONE AHEAD sign and is placed at least 1000 ft (300 m) before the beginning of the blasting zone.

[9] Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Electric Detonators (Blasting Caps), Safety Library Publication No. 20. Institute of Makers of Explosives, 1120 19th St., N.W., Suite 310, Washington, D.C. 20036-3605. Phone 202-429-9280.

21. END BLASTING ZONE Sign (W22-3)

The END BLASTING ZONE sign shall be placed a minimum of 1000 ft (300 m) past the blasting zone, either with or preceding the END ROAD WORK sign.

22. UNEVEN LANES Sign (W8-9b)

The UNEVEN LANES sign should be used during operations that create a difference in elevation between adjacent lanes.

23. Other Warning Signs

The signs pictured below may also be used to provide sufficient advance warning, either by themselves or with other advance warning signs.

Besides the warning signs specifically related to temporary traffic control zones, several other warning signs, most of which have been standardized in Part 2C of this manual, may apply in these zones. When used in temporary traffic control zones, warning signs shall have black legends on an orange background.

W1-4R
48" x 48"
1200mm x 1200mm

W5-1
48" x 48"
1200mm x 1200mm

W8-1
48" x 48"
1200mm x 1200mm

24. Advisory Speed Plate (W13-1)

In combination with a warning sign, an advisory speed plate may be used to indicate a recommended safe speed through the temporary traffic control zone. When used with orange temporary traffic control zone signs, this plate shall have a black legend and border on an orange background. It shall not be used with any sign other than a warning sign, nor shall it be used alone. The sign shall be at least 24"(600 mm) square in size when used with a sign 36" (900 mm) square or larger. Except in emergencies, an advisory speed plate (W13-1) shall not be mounted until the recommended speed is determined by the highway authority.

C. Guide Signs

1. Function and Design of Guide Signs

Guide signs are essential along streets and roadways to give drivers information that will help them in the most simple, direct manner possible. The design of guide signs is given in Part 2 of the Michigan MUTCD.

The following guide signs are required at temporary traffic control zones:

a. Standard route markings, where temporary route changes are necessary.

b. Directional signs such as motorist service signing, recreational and cultural interest area signs, civil defense signing, and street name signs. When used with detour routing, these signs may have a black legend on an orange background.

c. Special information signs relating to work being done. These signs shall have a black legend on an orange background.

2. Length of Work Sign (G20-1)

The Length of Work sign should be erected in advance of any temporary traffic control zone of more than two miles in length; it carries the legend ROAD WORK NEXT X MILES. The distance shall be stated to the nearest whole mile. The sign may also be used for jobs of shorter length.

3. END ROAD WORK Sign (G20-2)

The END ROAD WORK sign should be placed about 500 ft (150 m) past the work area. The sign may be erected on the back of a warning sign facing the opposite direction of traffic.

G20-1
60" x 24"
1500mm x 600mm

G20-2
48" x 24"
1200mm x 600mm

4. Signs Used for Detours (M4-8, M4-8a, M4-9, M4-10)

The DETOUR marker (M4-8) is intended to be used to mark a temporary route that branches from a regular numbered route, bypasses a section of a route which is closed or blocked by construction, major maintenance, roadway damage or traffic emergency, and rejoins the regularly numbered route beyond that section. It is to be mounted at the top of a route marker assembly.

The DETOUR ENDS sign (M4-8a) may be used to advise the motorist that the detour has ended. The DETOUR ENDS sign may be used on either numbered highways or unnumbered roadways. If used on a numbered highway, it should be erected above a route marker located near the end of the detour.

The DETOUR sign (M4-9) is intended for use in connection with an unnumbered street or highway that is to be detoured, or where, over relatively short distances, it is not necessary to show route numbers to guide traffic along the detour and back to its desired route. It is also intended for use in emergency situations and for periods of short duration. DETOUR signs, with appropriately oriented arrows, may be used along the detour to indicate points at which the detour changes direction. A Street Name sign (D3-1) may be placed above or incorporated in the DETOUR sign (M4-9) to indicate the name of the roadway for which the detour was established. The D3-1 may have a black legend on an orange background.

M4-8
24" x 12"
600mm x 300mm

M4-8a
24" x 18"
600mm x 450mm

M4-9R
30" x 24"
750mm x 600mm

M4-9S
30" x 24"
750mm x 600mm

G20-4
36" x 18"
900mm x 450mm

5. PILOT CAR sign (G20-4)

The Pilot Car sign shall be mounted in a conspicuous position on the rear of a vehicle used for guiding one-way traffic through or around a work space. The legend shall be PILOT CAR—FOLLOW ME. A traffic regulator shall be stationed on the approach to the activity area to stop traffic until the pilot car is available.

6F-2. PORTABLE CHANGEABLE MESSAGE SIGNS

A. Design

Portable Changeable Message Signs (PCMS) are traffic control devices with the flexibility to display a variety of messages to fit the needs of road and street authorities. Each message consists of one or more displays. Portable Changeable Message signs are used most frequently on high-density, urban freeways, but have applications on all types of highways where highway alignment and traffic routing problems require advance warning and information that cannot be easily installed on static signing and that cannot be duplicated on static signing.

1. Components

The components of a PCMS should include: message sign panel, control systems, power source, mounting and transporting equipment.

a. Message Sign Panel

PCMS cannot always conform to the exact sign shape, color and dimensions specified in these standards. PCMS should subscribe to the principles established in the manual, and to the extent practicable, with the design (i.e. color, letter size and shape, and borders) and applications prescribed herein. The message sign panel can vary in size and may consist of one, two, or three lines. High-density urban freeways typically use three lines of eight characters per line. Each character module shall use, as a minimum, a five wide-pixel by seven high-pixel matrix. The front face of the sign should be covered with a protective material. Element colors for warning messages should be black on a yellow or orange background; for guide messages, white on a green background or black on an orange background. Color reversals are also acceptable.

The sign should be visible from ½ mile (800 m) under ideal day and night conditions. Each sign message should be legible from a minimum of 650 ft (200 m) from all lanes. In the field, the PCMS should be sited and aligned to optimize driver performance. The message panel should have adjustable flash rates, so that the entire message can be read at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.

The sign shall automatically adjust its light source under different light level conditions, so as to meet the legibility requirements and not impair the drivers' vision.

b. Control System

The control system should include the following features:

- A display screen upon which messages can be reviewed before display on the message sign.
- A capability to provide an automatic programmed default message if power failure occurs.
- A backup battery to maintain memory when power is unavailable.

3. Power Source

The PCMS shall be equipped with a power source and a battery back-up.

d. Mounting

The mounting of the PCMS shall be such that the bottom of the message sign panel shall be a minimum of two meters above the roadway when it is in the operating mode.

B. Application

The primary purpose of PCMS in temporary traffic control zones is to advise the driver of unexpected traffic and routing situations. PCMS have a wide variety of applications in temporary traffic control zones, including roadway or ramp closures, accident or emergency incident management, width restriction information, advisories on road work scheduling, traffic management and diversion, warning of adverse conditions, and operation control. PCMS should be used with conventional signs, pavement markings, and lighting. Some typical applications include the following:

C. Placement

PCMS should be placed to be visible from at least 1/2 mile (800 m) under both day and night conditions. Placement in advance of the temporary traffic control zone or incident should, as much as possible, take into account the following factors:

- PCMS will typically be placed in advance of any other temporary traffic control zone signing and should not replace any required static sign messages.
- Where used for route diversion, PCMS should be placed far enough in advance of the work site to allow traffic ample opportunity to exit the affected highway.
- PCMS are normally placed level on the shoulder of the roadway, perpendicular to traffic. However, if practical, placement further from the traveled lane is desirable.
- When two signs are needed to communicate multiple messages, they should be placed on the same side of the roadway, separated by at least 1000 ft (300 m).

D. Messages

PCMS messages should be readily understood by drivers and thus will allow them adequate time to react. Messages should be designed taking into account the following factors:

- No more than two displays should be used within any message cycle.
- Each display should convey a single thought.
- Messages should be as brief as possible.
- When abbreviations are used, they should be easily understood.
- The entire message cycle should be readable at least twice at the posted speed, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.
- Messages shall not scroll horizontally or vertically across the face of the sign.

6F-3. ARROW DISPLAYS

An arrow display is a sign with a matrix of elements (usually light bulbs) powered by an on-board generator. The matrix, capable of flashing displays, is intended to provide additional warning and directional information to assist in merging and controlling traffic through or around a temporary traffic control zone. An arrow display should be used in combination with appropriate signs, barricades or other traffic control devices.

A. Arrow Panel Application

Arrow displays shall meet the size and other specifications of Figure 6-8.

Type A arrow displays are appropriate for use on low-speed urban streets. Type B are appropriate for intermediate-speed facilities and for maintenance or mobile operations on high-speed roadways. Type C arrow displays are intended to be used on high-speed, high-volume traffic control projects.

An arrow display shall be rectangular, of solid appearance, and finished in nonreflective black. The panel shall be mounted on a vehicle, a trailer, or other suitable support. A vehicle-mounted panel should be provided with remote controls. Minimum mounting height should be 7 ft (2.1 m) from the roadway to the bottom of the panel, except on vehicle-mounted panels, which should be as high as practicable.

An arrow display shall have the following mode selections:

1. A flashing arrow
2. Flashing Double Arrow mode
3. Flashing Caution mode

Arrow display elements shall be capable of a minimum 50 percent dimming from their full-rated lamp voltage. Full lamp voltage should be used for day, and dimmed mode shall be used for night.

The arrow display shall have suitable elements capable of the various operating modes. If an arrow panel consisting of a bulb matrix is used, the elements should be recess-mounted or equipped with an upper hood of not less than 180 degrees. The color presented by the elements shall be yellow.

Minimum element "on time" shall be 50 percent for the flashing mode. The flashing rate shall be no fewer than 25 nor more than 40 flashes per minute.

B. Arrow Display Application

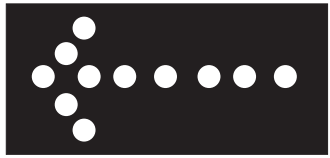
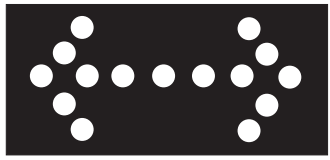
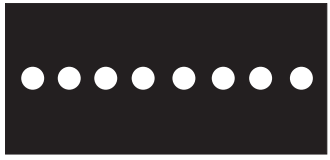
An arrow display in the arrow mode shall only be used for stationary or moving lane closures. The display in the caution mode shall be used only for shoulder work, blocking the shoulder, or roadside work near the shoulder, or at the Traffic Regulator stations when two way traffic is alternately using one lane or as an optional warning device in a closed lane.

For a stationary lane closure along a multilane roadway, the arrow display should be located on the shoulder at the beginning of the taper. When physical limitations restrict its' placement as indicated, then the arrow display should be placed as close to the beginning of the taper as possible.

Where the shoulder is narrow, the arrow display should be located in the closed lane. If arrow displays are used when multiple lanes are closed in tandem, the preferred position for additional arrow displays is in the closed lane at the start of the merge taper. Under various situations, such as for narrow shoulders, placement may be in the middle or at the end of the merge taper but always behind the channelizers. The panel shall be located behind any channelizing devices used to transition traffic from the closed lane.

For mobile operations where a lane is closed, the arrow display should be located to provide adequate separation from the work operation to allow for appropriate reaction by approaching drivers. A vehicle displaying an arrow display shall be equipped with appropriate signing and/or lighting.

An arrow display shall not be used on a two-lane, two-way roadway in arrow mode. The panel shall display the caution mode when used on these roadways.

Operating Mode	Panel Display* (Right shown: left similar)
I. At least one of the following modes shall be provided: Flashing Arrow.	
II. At least one of the following modes shall be provided: Flashing Double Arrow.	
III. At least one of the following modes shall be provided: Flashing Caution. *Element layout for Type C panel shown.	

Panel Type	Minimum Size Inches (Millimeters)	Minimum Legibility Distance	Minimum Number of Elements
A	48”x24” (1200 x 600)	½ mile (800m)	12
B	60”x30” (1500 x 750)	¾ mile (1200m)	13
C	96”x48” (2400 x 1200)	1 mile (1600m)	15

Figure 6-8. Advanced Warning Arrow Panel Specifications.

6F-4. HIGH-LEVEL WARNING DEVICES

The high-level warning device (flag tree) may supplement other traffic control devices in temporary traffic control zones. It is designed to be seen over the top of vehicles.

A high-level warning device shall consist of a minimum of two flags with or without a Type B high-intensity, flashing warning light. The distance from the roadway to the bottom of the lens of the light and to the lowest point of the flag material shall be no less than 8 ft (2.5 m). The flags shall be 16" (400 mm) square or larger and shall be orange or fluorescent versions of orange in color. An appropriate warning sign may be mounted below the flags.

High level warning devices are most commonly used in urban high density traffic situations to warn motorists of short-term operations.

6F-5. CHANNELIZING DEVICES

A. General

The function of channelizing devices is to warn and alert drivers of conditions created by work activities in or near the traveled way, to protect workers in the temporary traffic control zone, and to guide drivers and pedestrians safely. Channelizing devices include but are not limited to cones, tubular markers, vertical panels, drums, barricades, temporary raised islands, and barriers.

Devices used for channelization should provide for smooth and gradual traffic movement from one lane to another, onto a bypass or detour, or to reduce the width of the traveled way. They may also be used to separate traffic from the work space, pavement drop-offs, pedestrian paths, or opposing directions of traffic.

Channelizing devices should be constructed and ballasted to perform in a predictable manner when inadvertently struck by a vehicle. If struck, they should not inflict any undue damages to the vehicle that strikes them nor harm the workers nearby.

Spacing of channelizing devices in ft (meters) in the taper area should not exceed the posted speed in miles per hour (.3m) and twice the speed (.6m) in the parallel area.[e.g, a 45 mph posted speed road should normally have devices spaced no greater than 45 ft (13.5 m) apart in the taper area and 90 ft (27 m) in the parallel section].

Consideration should be given for warning lights on channelizing devices in fog or snow areas, severe roadway curvature, and unusually cluttered environments. Flashing lights may be placed on channelizing devices used singly or in very closely spaced groups to mark a spot condition. When called for, warning lights on channelizing devices used in a series for delineation shall be steady burn lights. The retro-reflectorized material used on channelizing devices shall have a smooth, sealed outer surface.

Channelizing devices are elements in a total system of traffic control devices for use in temporary traffic control zones. These elements shall be preceded by a subsystem of warning devices that are adequate in size, number, and placement for the type of highway on which the work is to take place. Standard designs of channelizing devices are shown in Figure 6-9.

The name and telephone number of the agency, contractor, or supplier may be shown on the non-retro-reflective surface of all channelizing devices. The letters and numbers shall be a non-retro-reflective color and not over 2" (50 mm) in height.

Particular attention should be given to assuring that channelizing devices are maintained and kept clean, visible and properly positioned at all times. Devices shall be replaced that are damaged and have lost significant amount of their retro-reflectivity and effectiveness.

B. Cones

1. Cone Design

Cones shall be predominantly orange, fluorescent red-orange, or fluorescent yellow-orange, not less than 18" (450 mm) high, and shall be made of a material that can be struck without damaging vehicles on impact. Cones shall be a minimum of 28" (700 mm) in height when they are used on freeways and other high-speed highways, on all highways during nighttime, or whenever more conspicuous guidance is needed.

For nighttime use, cones shall be retro-reflective or equipped with lighting devices for maximum visibility. Retro-reflection of 28" (700 mm) or larger cones shall be provided by a white band 6" (150 mm) wide, no more than 3 to 4" (75-100 mm) from the top of the cone, and an additional 4" 100 mm wide white band a minimum of 2" (50 mm) below the 6" (150 mm) band.

2. Cone Application

Traffic cones are used to channelize traffic, divide opposing traffic lanes, divide traffic lanes when two or more lanes are kept open in the same direction, and delineate short duration maintenance and utility work.

Steps should be taken to ensure that cones will not be blown over or displaced by wind or moving traffic. Cones can be doubled up to increase their weight. Some cones are constructed with bases that can be filled with ballast. Others have special weighted bases, or weights such as sandbag rings that can be dropped over the cones and onto the base to provide added stability. These weights should not be sufficient to cause harm to the motorist or workers if the devices are inadvertently struck.

C. Tubular Markers

1. Design

Tubular markers shall be predominantly orange, not less than 18" (450 mm) high not less than 2" (50 mm) wide, and made of a material that can be struck without damaging impacting vehicles. Tubular markers shall be a minimum of 28" (700 mm) in height when used on freeways and other high-speed highways, on all highways during nighttime, or whenever more conspicuous guidance is needed. For nighttime use, tubular markers shall be retro-reflective. Retro-reflection of tubular markers shall be provided by two 3" (75 mm) wide white bands placed a maximum of 2" (50 mm) from the top with a maximum of 6" (150 mm) between the bands.

2. Tubular Marker Application

Tubular markers may have less visible area than other devices and should be used only where space restrictions do not allow the use of other more visible devices. They may be used effectively to divide opposing lanes of traffic, divide traffic lanes when two or more lanes are kept open in the same direction, and delineate edge of pavement drop off where space limitations do not allow the use of larger devices.

Steps should be taken to assure that tubular markers will not be blown over or displaced by traffic by either affixing them to the pavement with anchor bolts or adhesive, using weighted bases, or weights that can be dropped over the tubular markers and onto the base to provide added stability. These weights should not be sufficient to cause harm to the motorist or workers if the devices are inadvertently struck. If a noncylindrical device is used, and it could be displayed with a width less than the minimum facing traffic, it shall be attached to the pavement to ensure that the width facing traffic meets the minimum requirements.

D. Vertical Panels

1. Design

Vertical panels shall be 8"-12"(200 to 300 mm) wide and at least 24" (600 mm) high. They shall have orange (fluorescent red-orange or fluorescent yellow-orange) and white stripes and be retro-reflective. Panel stripe widths shall be 6" (150 mm) except where panel heights are less than 36" (900 mm) then 4" (100 mm) stripes may be used. If used for two-way traffic, back-to-back panels shall be used.

Markings for vertical panels shall be alternating orange and white retro-reflectorized stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass). Vertical panels used on expressways, freeways, and other high-speed roadways shall have a minimum of 270 square inches (165,000 sq. mm) of retro-reflective area facing traffic.

2. Application

Vertical panels may be used to channel traffic, divide opposing lanes of traffic, divide traffic lanes or in place of barricades where space is limited.

E. Drums

1. Design

Drums used for traffic warning or channelization shall be constructed of lightweight, flexible, and deformable materials and be a minimum of 36"(900 mm) in height; and have at least an 18" (450 mm) minimum width, regardless of orientation. Steel drums shall not be used. The markings on drums shall be horizontal, circumferential, alternating orange and white retro-reflectorized stripes 4"to 6"(100 -150 mm) wide. Each drum shall have a minimum of two orange and two white stripes. Any non-retro-reflectorized spaces between the horizontal orange and white stripes, shall not exceed 2" (50 mm) wide. Drums shall have closed tops that will not allow collection of debris.

2. Application

Drums are most commonly used to channelize or delineate traffic flow but may also be used singly or in groups to mark specific locations. Drums are highly visible and have good target value, given the appearance of being formidable obstacles and, therefore, command the respect of drivers. They are portable enough to be shifted from place to place within a temporary traffic control project to accommodate changing conditions but are generally used in situations where they will remain in place for a prolonged period.

Drums should not be weighted with sand, water, or any material to an extent that it can cause harm to motorists, pedestrians, or workers, if struck. When they are used in regions susceptible to freezing, they should have drainage holes in the bottom so water will not accumulate and freeze. Ballast shall not be placed on top of the drum.

F. Barricades

1. Design

A barricade is a portable or fixed device having from one to three rails with appropriate markings. It is used to control traffic by closing, restricting, or delineating all or a portion of the right-of-way.

Barricades shall be of three types: Type I, Type II, or Type III.

Stripes on barricade rails shall be alternating orange and white retro-reflective stripes (sloping downward at an angle of 45 degrees in the direction traffic is to pass). The stripes shall be 6" (150 mm) wide, except where rail lengths are less than 36" (900 mm), then 4" (100 mm) wide stripes may be used. The minimum rail length is 24" (600 mm). Barricades used on expressways, freeways, and other high-speed roadways shall have a minimum of 270 square inches (165,000 sq. mm) of retro-reflective area facing traffic.

Where a barricade extends entirely across a roadway, the stripes should slope downward in the direction toward which traffic must turn. Where both right and left turns are provided, the stripes may slope downward in both directions from the center of the barricade or barricades. Where no turns are intended, the stripes should slope downward toward the center of the barricade or barricades.

Barricade rails should be supported in a manner that will allow them to be seen by the motorist and provide a stable support not easily blown over by the wind or traffic. For Type I barricades, the support may include other unstriped horizontal panels necessary to provide stability.

Barricades are located adjacent to traffic and therefore, subject to impact by errant vehicles. Because of their vulnerable position and the potential to become missiles when inadvertently struck, they should be constructed of lightweight materials and have no rigid stay bracing for A-frame designs.

On high-speed expressways or in other situations where barricades may be susceptible to overturning in the wind, sandbags should be used for ballasting. Sandbags may be placed on lower parts of the frame or stays to provide the required ballast but shall not be placed on top of any striped rail. Barricades shall not be ballasted by heavy objects such as rocks or chunks of concrete.

2. Barricade Application

Type I or Type II barricades are intended for use in situations where traffic is maintained through the temporary traffic control zone. They may be used singly or in groups to mark a specific condition or they may be used in a series for channelizing traffic. Type I barricades normally would be used on conventional roads or urban streets and arterials.

Type III barricades used at a road closure may extend completely across a roadway or from curb to curb. Where provision is made for access of authorized equipment and vehicles, the Type III barricades responsibility should be assigned to a person to ensure proper closure at the end of each work day.

When a highway is legally closed but access must still be allowed for local traffic, the Type III barricade cannot be extended completely across a roadway. A sign with the appropriate legend concerning permissible use by local traffic shall be mounted. (See Section 6F-1a). Signs may be erected on or above Type III barricades. The Road Closed and Detour Arrow signs, and the Large Arrow warning signs, for example, can be mounted effectively on or above the Type III barricade that closes the roadway.

G. Temporary Raised Islands

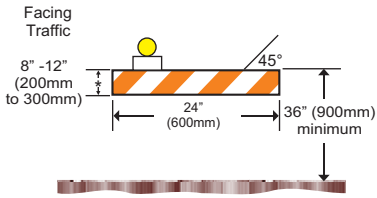
The temporary raised island should only be used on roadways with posted speeds of 45 mph or less except when recommended by an engineering study.

A temporary raised island may be used to separate traffic flows in two-lane two-way operations (TLTWO). The island may be used in combination with tubular markers and pavement stripping. Pavement edge lines may be placed on the island itself. It may also have application in other than TLTWO where physical separation of traffic from the work zone is not required.

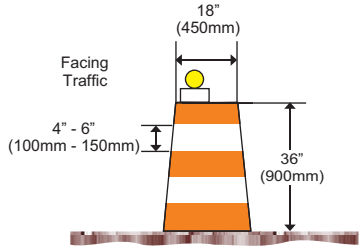
Temporary raised islands should have the basic dimensions of 4 inches (100 mm) high by 18 inches (450 mm) wide and have rounded or chamfered corners. They may be constructed of Portland cement concrete or bituminous concrete. They should be designed according to Chapter 9 of the AASHTO Roadside Design Guide.

H. Other Channelizing Devices

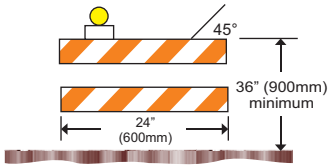
Channelizing devices, other than those specified above, may be required for special situations based on an engineering study. Such devices should conform to the general size, color, stripe, pattern, retro-reflection, and placement characteristics established for standard devices.



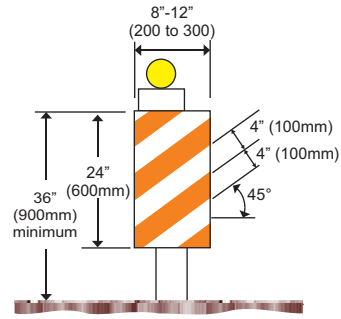
**TYPE I BARRICADE * *



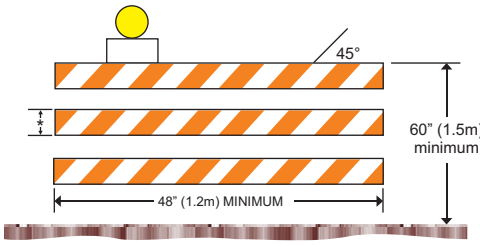
DRUM



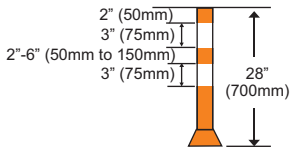
**TYPE II BARRICADE * *



VERTICAL PANEL



**TYPE III BARRICADE * *

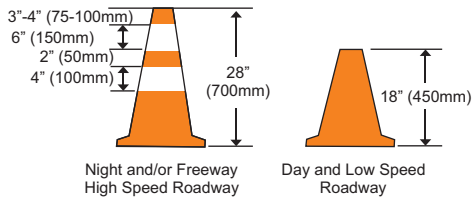


TUBULAR MARKERS

* NOMINAL LUMBER DIMENSIONS ARE SATISFACTORY FOR BARRICADE RAIL WIDTH DIMENSIONS 8" TO 12" (200 TO 300mm)

** STRIPE WIDTHS SHALL BE 6" (150mm) EXCEPT WHERE RAIL LENGTHS ARE LESS THAN 36" (900mm), THEN 4" (100mm) WIDE STRIPES MAY BE USED.

THE SIDES OF BARRICADES FACING TRAFFIC SHALL HAVE RETROREFLECTIVE RAIL FACES



CONES

Figure 6-9 Channelizing Devices and Object Markers.

6F-6. MARKINGS

A. Pavement Marking Applications

Pavement markings shall be maintained along paved streets and highways in temporary traffic control zones. Markings no longer applicable shall be removed or obliterated (as soon as practicable.) The work should be planned and staged to provide the best possible conditions for the placement and removal of the pavement markings.

It is intended, to the extent possible, that motorists be provided markings within a work area comparable to the markings normally maintained along such roadways, particularly at either end of the work area. The following guidelines set forth the level of markings and delineation for various work area situations.

1. All markings shall be in accordance with Part 3 of the MMUTCD except as indicated under 6F-6B (Temporary Markings of this manual).

2. Markings shall be maintained in long term stationary work areas and shall match the markings in-place at both ends of the work area.

3. Markings shall be placed along the entire length of any surfaced detour or temporary roadway before such detour or roadway being opened to traffic.

4. Centerline/lane lines should be placed or replaced or delineated where appropriate prior to the roadway being opened for traffic.

5. Markings should be provided in intermediate-term stationary work areas, to the extent practicable.

6. In any work area where it is not possible to provide a clear path by markings, appropriate warning signs, channelizing devices, and delineation shall be used to indicate the required vehicle paths.

7. **For Multi Lane (One Way) roadways where lane lines are used and No Passing Zones are established in the Traffic Control Plan (TCP) for the purpose of controlling lane merges, the DO NOT PASS signs shall have precedence over the existing pavement lane lines/markings.**

All markings and devices used to delineate vehicle and pedestrian paths shall be carefully reviewed during daytime and nighttime periods to avoid inadvertently leading drivers or pedestrians from the intended path.

Proper pavement marking obliteration leaves a minimum of pavement scars and completely removes old marking materials. Overlaying existing stripes with paint or asphalt does not meet the requirements of removal or obliteration, and is prohibited**.** The intended vehicle path should be clearly defined in day, night, and twilight periods under both wet and dry pavement conditions.

B. Temporary Markings

Temporary pavement markings are those that may be used until the earliest date when it is practical and possible to install pavement markings that meet the full MMUTCD standards for pavement markings. Normally, it should not be necessary to leave temporary pavement markings in place for more than two weeks. All temporary pavement markings, including pavement markings for no-passing zones, shall conform to the requirements of Sections 3A and 3B with the following exceptions:

1. All temporary broken line pavement markings shall use the same cycle length as permanent markings and be at least 4 ft (1.2 m) long, except that, half cycle lengths with a minimum of 2 ft. (0.6 m) stripes may be used for roadways with severe curvature (See Section 3A-6). This applies to white lane lines for traffic moving in the same direction and yellow center lines for two-lane roadways when it is safe to pass.

2. For those temporary situations of three calendar days or less for a two or three lane road, no-passing zones may be identified by using signs rather than pavement markings. Also signs may be used in lieu of pavement markings on low-volume roads for longer periods, when this practice is in keeping with the road agency's policy. These signs should be placed in accordance with Section 2B-20.

3. The temporary use of standard school zone, railroad, stop line and other pavement markings should be in keeping with the road agency's policy.

4. Temporary edge lines are not required on Interstate and other highways previously marked with edge lines when in keeping with the road agency's policy.(see Section 3B-6).

5. Raised pavement markers may be used as vehicle positioning guides, as supplements to, or as substitutes for pavement markings (see Sections 3B-14, 3B-15, and 3B-16). All raised pavement markers when used to substitute for pavement markings in work zones shall be retro-reflective, shall be the same color as the pavement markings for which they are substituted, and shall be visible during the daytime.

Each highway agency should develop a policy that will, within the scope of this Section provide a more detailed criteria and describe the conditions where temporary pavement markings will be used. This policy should include, but not be limited to, criteria, definitions of extended periods of time and traffic volume thresholds for low-volume roads.

C. Raised Pavement Markers

Retro-reflective raised pavement markers, or non-retro-reflective raised pavement markers supplemented by retro-reflective markers, may be substituted for, or used as a supplement to markings prescribed in Section 3A and 3B and Subsection B above.

Raised pavement markers should be considered for use along surfaced detour or temporary roadways, and other changed or new travel lane alignments, because of the need to accentuate changed travel paths and their wet weather performance capabilities.

D. Delineators

Delineators may be used in work areas to indicate the alignment of the roadway and to outline the required vehicle path through the work zone. Delineators, when used, shall be used in combinations with, or be supplemental to, other traffic control devices.

When used, delineators shall be mounted on suitable supports so that the reflecting unit is about 4 ft. (1.2 m) above the near roadway edge. The standard color for delineators used along both sides of two-way streets and highways and the right side of one-way roadways shall be white. Delineators used along the left side of one-way roadways shall be yellow. Spacing along roadway curves should be as set forth in Section 3A and 3B and should be such that several delineators are always visible to the driver.

6F-7. LIGHTING DEVICES

A. Function

Construction, maintenance and utility activities often create conditions on or near the traveled way which increase accident potential when drivers' visibility is reduced during the hours of darkness. Therefore, it is often desirable and necessary to supplement retro-reflectorized signs, barriers, and channelizing devices with lighting devices.

Four types of lighting devices are commonly used: floodlights, flashing warning beacons, steady-burning lights, and warning lights.

In work areas where a study indicates a nighttime accident problem can be corrected with area illumination, consideration may be given to providing roadway lighting to provide additional guidance to motorists through the work area.

B. Floodlights

On construction projects, floodlights have a limited but important application. Maintenance or construction activities on urban freeways are frequently required to be conducted during nighttime periods when traffic volumes are lower. Sometimes large construction contracts are also operated on a double shift basis requiring night work. When nighttime work is required for these or similar type projects, floodlights shall be used to illuminate traffic regulator stations, equipment crossings and other areas where existing light is not adequate for the work to be performed satisfactorily.

In no case shall floodlighting be permitted to glare, shine or be directed into the eyes of oncoming drivers. The adequacy of the floodlight placement and elimination of potential glare can best be determined by driving through and observing the floodlighted area from each direction on the main roadway after initial floodlight setup.

C. Flashing Warning Beacons (Flashing Electric Lights)

A Flashing Warning Beacon is a flashing yellow light [(minimum diameter 8 inches(200 mm)] used at points of increased accident potential to alert drivers' attention to these locations. When used, the Flashing Warning beacon should operate 24 hours a day.

On construction projects, because of the time and effort required to install and put these units into operation, they are used, generally, at locations where frequent changes would not be required.

On projects where an existing dual highway is being upgraded to freeway standards (which requires the use of crossovers to permit stage construction), flashing beacons have been used effectively to call drivers' attention to the path created by the channelizing devices. Similarly, the temporary terminus of a freeway (where all traffic is channelized into an exit) is a location where beacons have informed drivers of the speed reduction necessary in transitioning from freeway to local road operations.

Flashing Warning Beacons may be used singly or in groups containing more than one unit.

During normal daytime maintenance operations, the functions of flashing beacons are adequately provided for by rotating dome or strobe lights on maintenance vehicles. However, flashing beacons may be installed at locations where the daytime maintenance activity requires an obstruction to remain in the roadway at night. (See Section 4E-5).

D. Steady-Burning Lights

As used herein, steady-burning lights shall mean a series of low intensity yellow lights. They may be used to mark obstructions, but they are generally less effective than flashing lights for these uses because of the attention getting effect of the latter. However, if lights are needed to delineate the traveled way through and around obstructions in a work zone, the delineation shall be accomplished by use of steady-burning lights.

Steady-burning lights, placed in a line on appropriate channelizing devices, are effective in delineating the proper vehicle path through stage construction zones which require changing patterns of traffic movement.

The application of these devices during maintenance work is infrequent due to the generally short time nature of the work. a type of maintenance activity where steady-burning lamps could be utilized is the removal and replacement of a portion of a bridge deck. The lamps could be mounted on barricades and effectively aid in channelizing traffic around the work space.

E. Warning Lights

The light weight and portability of warning lights are advantages that make these devices useful as supplements to the guidance function of barricades and alerting drivers' attention to warning signs.

As used herein, warning lights are portable, lens directed, enclosed lights. The color of the light emitted shall be yellow. They may be used in either a steady-burn or flashing mode. Warning lights shall be in accordance with the current ITE Purchase Specification for Flashing and Steady-Burn Warning Lights.

Warning lights shall have a minimum mounting height of 36 inches (900 mm) to the bottom of the lens except when used on top of temporary concrete barrier. Type A Low Intensity Flashing Warning lights are most commonly mounted on barricades, drums, vertical panels or advance warning signs and are intended to continually warn drivers that they are approaching or proceeding through a work area.

Type B High Intensity Flashing Warning lights are normally used at the point of greatest restriction within the work zone or where roadside obstacles are nearest the line of vehicular travel. These locations are usually the point at which the taper of a temporary concrete barrier wall turns and becomes parallel to the traffic path. They are designed to operate 24 hours per day. Flashers shall not be used for delineation, as a series of flashers would tend to obscure the desired vehicle path.

Type C Steady-Burn lights are intended to be used to delineate the edge of the traveled way on detour curves, on lane changes, on lane closures and on other similar conditions.

Type A Low Intensity Flashing Warning lights and Type C Steady-Burn Warning lights shall be maintained so as to be capable of being visible on a clear night from a distance of 3000 ft. (900 m). Type B High Intensity Flashing Warning lights shall be maintained so as to be capable of being visible on a sunny day when viewed without the sun directly on or behind the device from a distance of 1000 ft. (300 m).

6F-8. OTHER DEVICES

A. Impact Attenuators

Impact attenuators are protective systems that mitigate the effects of errant vehicles by either smoothly decelerating the vehicle to a stop when hit head-on, or by redirecting the errant vehicle away from the work vehicle for glancing impacts. Impact attenuators in work zones protect the motorists from the exposed ends of barriers, fixed objects and other work vehicles.

Attenuators must pass acceptable performance testing and be designed for each application in order to ensure performance that will safely stop or redirect errant vehicles. Periodic inspection of these devices is necessary to assure that attenuators function as intended throughout their useful life or prompt repair/replacement is made when hit or damaged.

Two types of impact attenuators used in work zones are roadside attenuators and truck-mounted attenuators.

1. Roadside Attenuators

Roadside attenuators are used in the same manner as permanent highway installations to protect motorists from the exposed ends of barriers, fixed objects and other hazards. Two types of stationary attenuators are commonly used and must be designed for the specific application intended:

a. Redirective Type

The redirective type is an assembled unit designed to absorb vehicle impacts such that it may be impacted head-on and telescope toward the rear, and also be capable of absorbing side impacts by redirecting a vehicle.

This type of attenuator normally is used when the exposed object is narrow, or when space for a non-redirective type is unavailable, such as on surface streets near adjacent intersecting roadways. The attenuator width selected must be wider than the object it guards, but as close to the object width as possible, to prevent its lateral intrusion into the traffic lanes.

b. Non-Redirective Type

The non-redirective type shall be an inertial barrier system (sand filled,) or other acceptable energy absorbing device designed to stop errant vehicles safely. When this system is used, it must be placed in arrays that are a minimum of 30 inches (750 mm) wider than the object on the side where traffic is approaching. Special considerations should be given under any 2 way traffic conditions.

Non-redirective type impact attenuators must be checked frequently for vehicle impacts because, once hit, they may not function as designed for a second hit. When inertial barrier systems are impacted, the debris is scattered, site cleanup is needed and the attenuator must be restored.

2. Truck Mounted Attenuators (TMAs)

Trucks are often used as protective vehicles to protect workers or work equipment from errant vehicles. These protective vehicles must be located properly in advance of the workers and/or equipment. However, these protective vehicles are objects that may cause injuries to occupants of errant vehicles if they are not equipped with truck-mounted attenuators (TMAs).

TMAs capable of absorbing the impact of errant vehicles can be attached to the rear of these protective vehicles to reduce the severity of rear-end crashes. In order to do so, the protective vehicle must be positioned a sufficient distance upstream from the workers or equipment being protected to allow for appropriate vehicle roll ahead, but not too far that errant vehicles can travel around the vehicle and strike the protected workers/equipment. When in operation, the attenuator shall be in the full down and locked position. For stationary operations, the vehicle's parking brake shall be set, the manual transmission in gear, the automatic transmission in park, and where possible, the front wheels turned away from the work site. Turning the front wheels should be based on specific conditions at the work site, such that the after impact trajectory is into a safe area. Always consult the manufacturers operational specifications for use.

Truck-mounted attenuators should be used when work activities are on high speed roadway projects which are long, intermediate, and short-term stationary and other projects when the worker is in a vulnerable position, such as on scaffolding or an elevated lift, or a lane normally used by traffic.

B. Portable Barriers

Portable barriers are devices designed to prevent vehicular penetration from the traveled way to work areas behind the barrier. They may also be used to separate two-way traffic. These devices may be constructed of concrete, metal, or any material that can physically prevent vehicular penetration while minimizing occupant injuries.

Portable barriers serve an additional function of channelizing traffic. Use for a specific project should be determined by engineering analysis. However, the protective requirements of the work area, not the channelizing needs, govern the analysis of need. When serving the additional function of channelizing traffic, portable barriers should be of a light color for increased visibility. For nighttime, barriers shall be supplemented by standard delineation, markings or channelizing devices. More specific information on the use of portable barriers can be obtained from the American Association of State Highway and Transportation Officials (AASHTO) "Roadside Design Guide."[10]

Warning lights, reflectors, or tape may be mounted on continuous barriers. The first two yellow warning lights at the start of a continuous barrier may be Type A flashing. Subsequent warning lights on the barrier shall be Type C yellow steady-burning for channelization. When warning lights are used, they shall be Type C Steady Burn for channelization, and a Type B Hi -Intensity Yellow Flashing light shall be used at the point of tangency.

The effect of striking the ends of barriers should be minimized by use of impact attenuators or by flaring the ends of barriers from the traveled way to a point outside of the clear zone.

C. Temporary Traffic Signals

Temporary traffic signals can be used for special applications to control traffic flow at work zones. These applications include a highway intersection with a temporary haul road or equipment crossing, and work zones with alternate one-way traffic flow such as bridge construction.

All traffic signal and control equipment shall meet the standards and specifications prescribed in Part 4 of the MUTCD.

One-way traffic flow requires an all-red interval of sufficient duration for traffic to clear the portion of the temporary traffic control zone controlled by the traffic signals. To avoid the possibility of GREEN/GREEN conflict at each end of the temporary traffic control zone, the traffic signal shall be either hard-wired, controlled by radio signals, operated manually, or designed to employ other technology that will not allow conflicting signal displays.

[10] American Association of State Highway and Transportation Officials; 444 North Capitol Street, N.W., Suite 225; Washington, D.C.

D. Rumble Strips

Rumble strips are transverse strips of rough textured surface and may be used to supplement other existing standard or conventional traffic control devices. Rumble strips may be used to alert drivers of unusual or unexpected traffic conditions or geometrics or to bring the driver's attention to other warning devices. They provide a tactile and audible warning which supplements visual stimuli.

A rumble strip may consist of raised strips or depressed grooves. The maximum height or depth should be 0.5 inches (12 mm). The cross section may be rectangular, domed or trapezoidal in shape. There should be five to twenty grooves or raised strips placed in a rumble strip. The raised strips or grooves should be placed transverse to the direction of traffic. An installation should consist of 3 to 10 rumble strips. The intervals between rumble strips should be reduced as the distance to the special condition diminishes to create a sensation of acceleration to the motorists.

The first rumble strip should be placed in advance of the advance warning devices. The last rumble strip should be placed a minimum of 250 ft (80 m) in advance of the traffic condition, gore, work space, or stop position. Rumble strips should not be placed on short horizontal or vertical curves. Rumble strips may be portable devices.

A sign warning drivers of the presence of rumble strips may be placed in advance of the strips.

E. Glare Screens

Glare screening is used to block the driver's view of activities that can distract from the driving task. Glare Screening also contains the work area and keeps dust and debris off the pavement. Glare screens are primarily useful on long-term construction projects.

Glare screens may improve safety and traffic flow where traffic volumes approach the roadway capacity because they discourage "gawking" and reduce headlight glare from oncoming traffic.

Glare screens may be mounted on the top of portable concrete barriers that separate two-way traffic. Glare Screens should not be mounted where they could restrict driver visibility and sight distance. Additional information regarding screens can be obtained from chapter 9 of the AASHTO Roadside Design Guide[11]

F. Opposing Traffic Lane Divider

Opposing traffic lane dividers are delineation devices used to separate opposing traffic on a two lane, two-way roadway. The upright, orange-colored panel shall be approximately 12 inches (300 mm) wide by 18 inches (450 mm) high. The symbol legend on the divider shall be two opposing arrows, similar to those on the two-way traffic warning sign (W6-3).

[11] Ibid.

6G. SELECTING TEMPORARY WORK ZONE TRAFFIC CONTROL

Section 6 G details selecting temporary work zone traffic control based on roadway type, location of work and duration of work. The selection of the most appropriate work-zone traffic control, and modifications that may be required, requires a knowledge and understanding of the situation at each temporary traffic-control zone. Although there are many ways of categorizing temporary traffic-control zone applications, the most critical three factors, roadway type, location of work, and duration of work, are detailed in this section and the typicals illustrated in Section 6H.

A. Roadway Type

1. Two-Lane Two-Way
2. Multi-Lane Undivided
3. Multi-Lane Divided
4. Freeways

B. Location of Work

1. Outside of Shoulder
2. On the Shoulder
   - No Encroach on Traveled Way
   - Minor Encroach on Traveled Way
3. On the Median of a Divided Roadway
4. On the Traveled Way
   - Within an Intersection
   - Rural Two Lane
   - Urban Streets or Arterials
   - Rural or Urban Multi-Lane
   - Freeways

C. Duration of Work

1. Long-Term Stationary
2. Intermediate-Term Stationary
3. Short-Term Stationary
4. Short Duration
5. Mobile
   - Intermittently
   - Continuously

Each traffic-control zone is different. Many variables, such as roadway type, location of work, duration of work, posted and operating speed, volume, vertical and horizontal alignment, pedestrians, and intersections affect the needs of each zone. The goal of traffic control in work areas is to provide for the safe and efficient movement of motorists through the work zone. The key factor in making the temporary traffic-control zone safe is sound judgment in applying proper work zone traffic control with consideration given to the motorists traveling through, and the workers in, the work zone.

Bicyclists and pedestrians also need guidance. If a bicycle or pedestrian path is closed because of work in progress, a signed alternate route should be provided. Bicyclists should not be directed onto the same path used by pedestrians. See Part 9 of the MMUTCD for details on controlling bicycle traffic.

6G-1 ROADWAY TYPE

Roadway type is a primary factor in determining the type, location, size and duration of temporary work zone traffic-control devices. Consideration shall be given to traffic volumes, posted and operating speeds, horizontal and vertical alignment and if the roadway is urban or rural.

Rural two-lane highways are characterized by relatively low volumes and higher operating speeds. Intersecting crossroads are generally spaced at one-mile intervals and residential and commercial driveways are generally lower in number and spaced at greater distance. Urban arterials often have lower speeds but they may require significant controls due to higher traffic volumes and closer spacing of design features such as intersections. Other urban streets with light traffic volumes will generally require fewer but more closely spaced devices. Major arterials and freeways need the highest type of traffic control primarily because of high speeds and often high volumes of traffic.

6G-2 LOCATION OF WORK

The choice of traffic control needed for a temporary traffic-control zone depends upon where the work is located. As a general rule, the closer the work is to traffic, the more control devices are needed.

Work can take place in the following six locations:

A. Outside of the Shoulder Edge

When work is being performed beyond the shoulder yet within the right-of-way, little or no temporary traffic control may be needed. Warning to traffic depends primarily on the work vehicle having its flashing, rotating or oscillating beacons, or strobe lights in operation. Devices may not be needed if work is confined to an area 15 ft (4.5m) or more from the edge of the shoulder. A general warning sign such as ROAD WORK AHEAD may be used if workers and equipment must occasionally move closer to the highway. If vehicles park on the shoulder, a SHOULDER WORK or SHOULDER CLOSED sign shall be used. If vehicles use the shoulder to access the work site or on occasion need to travel on or cross the roadway, a ROAD WORK AHEAD sign shall be used. If the equipment travels on the shoulder, on the roadway or crosses the roadway, it shall be equipped with, and have in operation, flashing lights and properly display a slow-moving vehicle symbol. Roadside mowing, right-of-way fence repair and tree planting are typical of this type of work activities. If the activity is spread out over a distance of more than 2 miles, signs shall be repeated every 2 miles. A supplementary panel with the message NEXT X MILES should be placed below the initial warning sign.

B. On the Shoulder

The shoulder should be signed as if work were on the road itself, since it is part of the driver's "recovery area". Advance warning signs shall be used. Channelizing devices shall be used to close the shoulder, direct traffic, and keep the work space visible to the motorist. Portable barriers may be used to prevent encroachment of errant vehicles into the work space and to protect workers. When the shoulder is not occupied but work has adversely affected its condition, the LOW SHOULDER or SOFT SHOULDER sign should be used, if appropriate. Where the condition extends over a distance in excess of 1 mile, the sign should be repeated at 1 mile intervals. In addition, a supplementary plate bearing the message NEXT X MILES may be placed below the first such warning sign.

On multi-lane, divided highways, signs advising of shoulder work or the condition of the shoulder should be placed only on the shoulder that is closed or affected by the work operation.

B-1. On the Shoulder No Encroachment on Traveled Way

There is no direct interference with traffic. When a shoulder is closed or occupied, warning is needed to advise the driver, delineate the work area, and protect the workers. This may require the use of portable barriers if work is directly adjacent to the travel lane. As a minimum, the warning signs SHOULDER WORK or SHOULDER CLOSED are adequate. When work is performed on a paved shoulder 8 ft (2.3m) or less in width, a shoulder taper of 1/3 L may be used. When work is performed on a paved shoulder 8 ft. (2.4m) or more in width, a shoulder taper of 1/3 L shall be used. When paved shoulders having a width of 8 ft. (2.4m) or more are closed on freeways and expressways, it should be treated as a closure of a portion of the road system because drivers expect to be able to use it in emergencies.

Motorists shall be given advance warning that shoulders are closed to use as refuge areas throughout a specified length of the approaching temporary traffic-control zone. An initial general warning sign is needed (e.g., ROAD WORK AHEAD), followed by a RIGHT or LEFT SHOULDER CLOSED sign. Where the end of the shoulder closure extends beyond the distance which can be perceived by motorists, a supplementary plate bearing the message NEXT X FEET or MILES should be placed below the SHOULDER CLOSED sign. A lighted arrow panel flashing in the "caution" mode shall be used.

B-2. On the Shoulder Minor Encroachment in Traveled Way

When the proposed work takes up part of a traffic lane, traffic volumes, vehicle mix (busses, trucks, and cars), speed, and capacity, shall be analyzed to determine whether the minor encroachment will be allowed or if the affected lane shall be closed. The lane encroachment should permit a remaining lane width of 10 ft (3 m) or the lane should be closed. However, 9 ft. (2.7 m) is acceptable for short-term use on low volume, low-speed roadways for traffic that does not include longer and wider heavy commercial vehicles. Minimum signing shall be as detailed in paragraph B-1. Cones or plastic drums shall be used to close the shoulder (with a shoulder taper of 1/3 L), to define the minor encroachment area and to separate traffic from the work area.

C. On the Median of a Divided Highway

Work in the median may require traffic control for both directions of traffic, using advance warning signs on both side of the roadway, channelization devices, and, if the median is narrow, portable barriers.

D. Within the Intersection

The typical traffic control application for intersections are classified according to the location of the work space with respect to the intersection area (as defined by the extension of curb or edge lines). There are three classifications: near side, far side and in-the-intersection. A Traffic Control Plan that details the required traffic control devices and changes in operation shall be developed and used.

For work at an intersection, advance warning signs, devices, and markings are to be used as appropriate on all cross streets. The effect of the work upon signal operation should be considered, such as signal phasing for adequate capacity and for maintaining or adjusting detectors.

Traffic-control zones in the vicinity of intersections may block movements and interfere with normal traffic flows. Such conflicts frequently occur at more complex signalized intersection having such features as traffic signal heads over particular lanes, lanes allocated to specific movements, multiple signal phases, and signal detectors for actuated control. When directing traffic within the intersection itself, consideration should be given to utilizing a uniformed police officer. Where the 85th percentile speed of traffic exceeds 40 mph, additional warning signs may be needed in the advance warning area.

It should be recognized that some work spaces may extend into more than one portion of the intersection. For example, work in one quadrant may create a near-side work space on one street and a far-side work space on the cross street. In such instances, the traffic-control zone should incorporate features shown in two or more of the intersection and pedestrian typical application diagrams shown in Section 6H.

D-1. Near Side of an Intersection

When a lane is closed on the approach side of an intersection, standard lane closure and taper techniques apply. A turn lane may be used for through traffic. Where space is restricted, as with short block spacings, two warning signs may be used in the advance warning area, and a third “action-type” warning or regulatory sign (e.g., KEEP LEFT) is placed within the transition area. The one significant problem that may occur with near-side lane closure is a reduction in capacity, which during certain hours of operation could result in congestion and backups.

D-2. Far Side of an Intersection

Far-side work spaces require additional treatment, because motorists typically may enter the activity area by straight-through and left or right turning movements. Merging movements within the intersection should be avoided. Therefore, the applicable principle is to close any lanes on the near-side intersection approach which do not carry through the intersection as lanes. If, however, there is a significant number of vehicles turning from this lane, then it may be advantageous to convert the lane to an exclusive turn lane.

D-3. In the Intersection

Work in the intersection will require a complete review of existing traffic control devices, pedestrian volumes and movements and traffic volumes and traffic movements into and through the intersection. Several items shall be reviewed and included, if appropriate, as part of the Traffic Control Plan. The proposed work may be restricted to non-peak periods or night time work. If the proposed work must take place during daylight hours or the traffic control devices must remain in place during peak traffic periods, then the existing traffic-control devices shall be reviewed to determine if they are to be modified, replaced with different types of devices or are to remain the same. Traffic regulators or uniformed police officers may be used to direct traffic and assign right-of-way in the intersection. If a traffic regulator or uniformed police officer is used to assign right-of-way at a signalized intersection, then the traffic signal shall be turned off and the heads covered.

The work space should be kept as compact as possible to allow greater freedom for traffic to move around the worksite. Completing the work in stages will also keep the work space compact. It may be appropriate to reduce traffic volumes or certain turning movements by lane restrictions in advance or the intersection or prohibiting and detouring certain movements.

E. On the Traveled Way

Work on the traveled way demands optimum protection for workers and maximum advance warning for drivers. Advance warning shall provide a general message that work is taking place, information about specific hazards, and actions the driver must take to drive through the temporary traffic-control zone.

E-1. On the Traveled Way - Rural Two-lane Two-Way

When one lane of a two-lane road is closed, the remaining lane must accommodate both directions of travel. The typical procedure for short-term work is to utilize traffic regulators to alternate traffic flow. For long-term operations, a temporary traffic signal is an alternative. For low traffic volumes, low speed roadways, where traffic may be self-regulating, a "Yield to Oncoming Traffic" traffic control operation may be used.

E-2. On the Traveled Way - Urban Streets or Arterials

Work on urban streets or arterials should be divided into segments to reduce potential conflicts with crossroads and commercial driveways. Stage constructions and night work shall be considered. A traffic control plan shall indicate how to control vehicular traffic, how many lanes are required, or whether any turns should be prohibited at intersections. Pedestrian traffic must be considered. If work will be done on the sidewalk, will it be necessary to close the sidewalk and assign the pedestrians to another path? The traffic control plan shall indicate how to maintain access to business, industrial, and residential areas. Even if the road is closed to vehicles, pedestrian access and walkways must be provided.

When an entire roadway is closed, a detour shall be provided and traffic shall be advised in advance of the closure. If local traffic is allowed to use the roadway up to the closure, the ROAD CLOSED TO THRU TRAFFIC (R11-4) or the ROAD CLOSED XX MILES AHEAD LOCAL TRAFFIC ONLY (R11-3) sign shall be used. The portion of the road open to local traffic should have adequate signing, marking, and protection.

Detours shall be signed so that traffic will be able to get through the entire area and back to the original roadway. Proper regulatory and warning signs shall be placed on the detour route.

E-3. On the Traveled Way - Rural or Urban, Multi-lane Divided and Undivided Non-Access Controlled

This section describes typical applications for work on multi-lane (4 or more) streets or highways. It is divided into right-lane closures, left-lane closures, multiple-lane closures, and closures on five-lane roadways.

When a lane is closed on a multi-lane road, a transition area containing a merging taper is needed. Typically, the advance warning area contains three warning signs, such as ROAD WORK AHEAD, RIGHT or LEFT LANE CLOSED AHEAD and the Lane Reduction Transition sign.

When an interior lane is closed for use as a work space, consideration should be given to also closing an adjacent lane. This procedure provides additional space for vehicles and materials and facilitates the movement of equipment within the work space. On multi-lane undivided roads and streets where the left lane is closed, such additional space can be obtained by also closing the left lane in the opposing direction.

Portable concrete barriers are not in themselves traffic-control devices, but, if placed along an adequate taper, transition, or tangent section, they may serve as traffic-control devices to provide guidance and warning to passing traffic. In serving this traffic-control function, portable barriers must be equipped with appropriate channelizing devices, delineation, and/or other traffic-control devices in order to perform well during day and night operations.

When determined necessary by an engineering analysis, barriers should be used for added safety by preventing travel of errant vehicles beyond their designated travel lanes. The four primary functions of barriers are:

(a) To keep traffic from entering work areas, such as excavations of material storage sites.
(b) To provide protection for workers and pedestrians.
(c) To separate two-way traffic.
(d) To protect construction such as false work for bridges and other exposed objects.

E-3A. Right Lane Closed

A minimum of three advance warning signs should be used to close a lane (RWA, RLCA, Lane Transition). A lighted arrow panel flashing in the "arrow" mode shall be used. If traffic volumes are high, traffic may back up. If morning and evening peak hourly traffic volumes in the two directions are uneven and the greater volume is on the side where the work is being done, the inside lane for opposing traffic may be closed and made available to the side with heavier traffic. A volume check in both directions should be made before this method is used.

If the heavier traffic changes to the opposite direction, the traffic control can be changed to allow two lanes for opposing traffic by moving the devices from the opposing lane back to the centerline. If these changes occur frequently, cones or tubes should be used at close spacing to emphasize lane lines and the centerline.

E-3B. Left Lane Closed

A minimum of three advance warning signs should be used to close a lane (RWA, LLCA, Lane Transition.) A lighted arrow panel flashing in the "arrow" mode shall be used. If the work activity can be contained entirely within the left (or inside) lane, it may be appropriate to close only that lane. Channelizing devices should be placed along the centerline and outside of the work activity to give advance warning to the opposing traffic. An alternative is to close the center lane and an adjacent lane, to give motorists and workers additional protection and to provide easier access to the work space. Overall safety needs, evaluated on the basis of existing traffic volumes and speeds in each direction, is the main factor for determining altematives.

E-3C. Multiple Lanes Closed

When the work occupies multiple lanes for one direction of traffic, the number of lanes remaining open may be reduced to one for each direction. A capacity analysis is necessary before this method is initiated. Traffic should be moved over one lane at a time and the tapers should be separated by a distance of 2L. When a roadway must be closed on a divided highway, a median crossover may be used (see Section 6G-9) subsections (b) and (c). When the directional roadway is closed, inapplicable WRONG WAY signs and markings, and other existing traffic-control devices at intersections within the temporary two-lane, two-way operation (TLTWO) section should be covered, removed, or obliterated.

E-3D. Five-Lane Roads

Traffic control for lane closures on five-lane urban or rural roads is similar to other multi-lane undivided roads.

F. Work Within Traveled Way - Freeways

Serious problems of traffic control may occur under the special conditions encountered where traffic must be moved through or around temporary traffic-control zones on high-speed, high-volume roadways. Although the general principles outlined in the previous sections of the manual are applicable to all types of highways, special consideration should be given to modern, high-speed, access-controlled highways to accommodate traffic in a safe and efficient manner that also adequately protects work forces. The density of traffic on these facilities requires that the most careful traffic-control procedures be implemented, for example, to induce critical merging maneuvers well in advance of work spaces and in a manner which creates minimum delay in the traffic stream. These situations may require more conspicuous devices than specified for normal rural or urban street use. However, the same important basic considerations of uniformity and standardization of general principles apply for all roadways.

Traffic controls for short duration and mobile operations are described in Sections 6F-1 and 6F-3. Flashing arrows or beacons mounted on the work vehicles are minimal requirements.

F-1. Problem Areas

The conduct of work under high-speed, high-density traffic on controlled access highways is complicated by many of the design and operational features inherent to their use.

The presence of median dividers which establish separate roadways for directional traffic also may prohibit the closing of that roadway or the diverting of traffic to other lanes. A typical layout for shifting traffic lanes around a work space is shown in Section 6H.

Lack of access to and from adjacent roadways prohibits rerouting of traffic away from the work space in many cases.

A major consideration in the establishment of traffic control is the vehicular speed differential which exists and the limited time available for drivers to react safely to unusual conditions while still providing an activity area that protects workers. Traffic control for a typical lane closure, for multiple and center lane closures and the preferred method for closing a center lane when the open lanes have the capacity to carry traffic are shown in Section 6H.

Other conditions exist where work must be limited to night hours, thereby necessitating increased use of warning lights, illumination of work spaces, and advance warning systems. Given these circumstances, the following sections emphasize some of the special considerations in the application of devices for control of traffic.

F-1A. Two-Lane, Two-Way Traffic on a Normally Divided Highway (TLTWO)

Two-lane, two-way operations (TLTWO) on one roadway of a normally divided highway is a typical application that requires special consideration in the planning, design, and construction phases. As unique operational problems (for example, increasing the risk of head-on collisions) can arise with the TLTWO, this typical application will be discussed here in a greater detail than the other typical applications.

The traffic-control plan shall include provisions for the separation of opposing traffic whenever two-way traffic must be maintained on one roadway of a normally divided highway. Two-way operation on one roadway of a normally divided highway shall be permitted only when other methods of traffic control have been determined not to be feasible.

When traffic control must be maintained on one roadway of a normally divided highway, opposing traffic shall be separated either with portable barriers (concrete safety-shape or an approved alternate), or with channelizing devices throughtout the length of the two-way operation. The use of striping and complementary signing, by themselves, is prohibited

Treatments for entrance and exit ramps within the two-way roadway segment of this type of work are shown in Section 6H.

F-1B. Crossovers

The following are considered guiding principles for the design of crossovers:

1. Crossovers should be designed for speeds not less than ten miles per hour below the posted speed prior to work starting, the off-peak 85th percentile speed prior to work starting, or the anticipated operating speed of the roadway, unless unusual site conditions require that a lower design speed be used.
2. Tapers for lane drops should not be contiguous with crossovers.
3. An array of channelizing devices, delineators, and full-length, properly placed pavement markings are important in providing drivers with a clearly defined travel path.
4. Portable concrete barriers and the excessive use of traffic-control devices cannot compensate for poor geometric design of crossovers.
5. The design of the crossover should accommodate all roadway traffic including trucks and buses.
6. A clear area should be provided adjacent to the crossover.

F-1C. Interchanges

Access to interchange ramps on limited-access highways should be maintained even if the work space is in the lane adjacent to the ramps. If access is not possible, ramps may be closed by using signs and Type III barricades. Early coordination with officials having jurisdiction over the affected cross streets is needed prior to ramp closures.

Access to exit ramps should be clearly marked and outlined with channelizing devices. For long-term projects, old pavement markings should be removed and new ones placed. As the work space changes, the access area may be changed.

When a work space interferes with an entrance ramp, a lane may need to be closed on the freeway. Work in the entrance ramp may require shifting ramp traffic.

6G-3 DURATION OF WORK

Work duration is a major factor in determining the number and types of devices used in temporary traffic-control zones. The duration of a temporary traffic-control zone is defined relative to the length of time a work operation occupies a spot location. When any part of the roadway is obstructed or closed, for a short-term stationary work or longer, advance warning signs to alert traffic are required well in advance of these obstructions or restrictions. The five categories of work duration and their time at a location are as follows:

A. Long-Term Stationary - Work That Occupies a Location More than Three Days.

Long-term stationary temporary traffic-control zones require the use of a complete set of advance warning signs. There is ample time to install and realize benefits from the full range of traffic-control procedures and devices that are available for use. Generally, larger channelizing devices are used, as they have more retro-reflective material and offer better nighttime visibility. The larger devices are also less likely to be displaced or tipped over, an important consideration during those periods when the work crew is not present to maintain the zone. Furthermore, since long-term operations extend into nighttime, retro-reflective and/or illuminated devices are required. Temporary roadways and barriers can be provided, and inappropriate markings should be removed and replaced with temporary markings.

B. Intermediate-Term Stationary - Work That Occupies a Location from Overnight to Three Days.

Intermediate-term stationary work requires the use of a complete set of advance warning signs. It may not be feasible or practical to use procedures or devices that would be desirable for long-term stationary temporary traffic-control zones, such as altered pavement markings, barriers, and temporary roadways. The increased time to place and remove these devices in some cases could significantly lengthen the project, thus increasing exposure time. In other instances, there might be insufficient pay-back to make more elaborate traffic control economically attractive.

C. Short-Term Stationary - Daytime Work That Occupies a Location from One to Twelve Hours.

Short-term stationary work requires the use of a complete set of advance warning signs. The work crew is present to maintain and monitor the temporary traffic-control zone. The use of traffic regulators is a practical and available option. Lighting and/or retro-reflective devices should be incorporated to accommodate varying seasonal, climatic, and visibility situations.

D. Short-Duration and Mobile Operations

As compared to stationary operations, short-duration and mobile operations are distinct activities that may involve different treatments. More mobile devices are needed (e.g., signs mounted on trucks), and larger, more imposing and more visible devices can be used effectively and economically. For example, appropriately colored and marked vehicles with flashing or rotating lights, perhaps augmented with signs or arrow panels, may be used in place of signs and channelizing devices. The trade-off is economical because work duration is short. Mobility is essential, the crew is always on-site, and some of the vehicles may be required for the work activity or crew transportation. Safety is not compromised, as numerous small devices are merely replaced by fewer more dominant and effective devices.

D-1. Short Duration - Work that occupies a location up to one hour

Short-duration activities are generally considered to be those where it takes longer to set up and remove the traffic-control zone than to perform the work. Typically, such operations can be accomplished in 60 minutes or less.

There is significant time and exposure involved for the crew in setting up and taking down a traffic-control zone. Also, since the work time is short, the time during which motorists are affected is significantly increased when additional devices are installed and removed. Considering these factors, it is generally held that simplified control procedures are warranted for short-duration activities. Such shortcomings may be offset by the use of other more-dominant devices, such as special lighting units on work vehicles.

D-2. Mobile - Intermittently or Continuously

Intermittently moving mobile operations are work activities that often involve frequent short stops, each as much as 15 minutes long, for activities such as litter cleanup, pothole patching and sign installations. Warning signs, flags, and channelizing devices should be used. Flashing vehicle lights shall be used.

Continuously moving mobile operations include work activities where workers and equipment move along the road without stopping, usually at slow speeds for such activities as street sweeping, mowing and pavement marking. The advance warning area moves with the work area. Warning signs, flags and channelizing devices may not be required. Flashing vehicle lights shall be used.

For intermittently moving and continuously moving mobile operations a minimum of a well-marked and well-signed vehicle with flashing rotating or strobe lights is required. A protection vehicle equipped as a sign truck, preferably supplied with a flashing arrow panel, should follow the work vehicle when traffic volumes, traffic speeds or visibility dictate increased protection. Where feasible, warning signs should be placed along the roadway and moved periodically as the work progresses. In addition, vehicles may be equipped with flags, truck-mounted attenuators and appropriate signs.

It must be emphasized that safety should not be compromised by using fewer devices simply because the operation will frequently change its location. Portable devices should be used. Traffic regulators may be used, but caution must be exercised so they are not exposed to an unnecessary increase in accident potential. The control devices should be moved periodically to keep them near the work area. If mobile operations are in effect on a high-speed travel lane of a multi-lane divided highway, flashing arrow panels shall be used.

6G-4 CONTROL OF TRAFFIC THROUGH INCIDENT AREAS

The primary function of traffic control at an incident area is to move traffic safely and expeditiously through or around the incident. An incident is an emergency traffic occurrence, natural disaster, or special event. Examples include a stalled vehicle blocking a lane, a traffic accident blocking the traveled way, a hazardous chemical spill closing a highway, floods and severe storm damage, a planned visit by a dignitary, or a major sporting event.

Emergencies and disasters may pose severe and unpredictable problems. The ability to install proper traffic control may be greatly reduced in an emergency and any available devices on hand may be used for the initial response. If the situation is prolonged, the standard procedures and devices set forth in this part of this manual shall be used. Special events, on the other hand, can be properly planned for and coordinated. This part of the MMUTCD provides standards for the proper procedure for closing portions or entire roadways in conjunction with such activities.

During incidents, longer vehicles may need to follow a different route than automobiles because of bridge, weight, clearance, or geometric restrictions. Also vehicles carrying hazardous materials may need to follow a different route from other vehicles.

The control of traffic through incident areas is an essential part of fire and enforcement operations. For these operations there must be adequate legislative authority for the implementation and enforcement of needed traffic regulations, parking controls, and speed zoning. Such statutes should provide sufficient flexibility in the application of traffic control to meet the needs of the changing conditions in incident areas.

Maintaining good public relations is necessary. The cooperation of the news media in publicizing the existence of and reasons for incident areas and their traffic control can be of great assistance in keeping the motoring public well informed.

Street or highway incident management signs fall into two major categories: regulatory signs and warning signs. Specifications for incident sign design are presented in Section 6F-1.

The channelizing devices discussed in Section 6F-5 should be used whenever possible. Flares may be used to initiate traffic control at all incidents or for short-term traffic control such as clearing incident sites, but should be replaced by more permanent devices as soon as practicable.

A short-term road closure caused by an incident such as a traffic accident may block the traveled way. Traffic may be detoured around the incident and back to the original roadway. The local traffic engineering department will probably be needed to determine the detour route and install the signs. Large trucks are a primary concern in such a detour.

An incident such as a hazardous chemical spill may require closure of an entire highway. Local traffic can adjust to the closure, but through traffic must be guided around the incident and back to the original route.

6G-5. DETOURS

A traffic control plan shall be developed to indicate if a road can be closed, how it shall be closed, the detour route and all temporary traffic-control devices that shall be used. Traffic shall not be placed on the detour route until permission is granted from the authority having jurisdiction over the roadway.

Detour signing is usually designed by the traffic engineer with authority over the roadway because it is considered a traffic routing problem. Detour signs are used to direct traffic onto another roadway. When the detour is long, signs should be installed to periodically remind and reassure drivers that they are still on a detour. This is done by using the Detour Marker (M4-8) or Detour (M4-9) signs.

The Michigan Vehicle Code (Sections 247.291 and 247.292) state:

CLOSING HIGHWAYS FOR CONSTRUCTION OR REPAIR; BARRIERS DEFINED

"The officials in charge of constructing, improving or repairing highways may close any highway or portion thereof, which is under process of construction, improvement or repair or upon which is located any bridge which is being constructed or repaired. No highway shall be closed under the provisions of this act until suitable barriers have been erected at the ends of the highway or of the closed portion thereof and also at the point of intersection of such highway or portion hereof with other highways. Suitable barriers are those which conform to the Michigan Manual of Uniform Traffic-Control Devices, adopted pursuant to section 608 of Act No. 300 of the Public Acts of 1949, being section 257.608 of the compiled laws of 1948. For the purposes of this act "highway" includes roads and streets.

DETOURS, NOTICES, REMOVAL OF BARRIERS ON COMPLETION OF WORK

No highway shall be closed under provisions of this act until suitable detours around the same, or the closed portion thereof, are provided and placed in reasonably safe and passable condition for traffic. Notices in the form of plainly legible signs shall be placed by the highway officials having such work in charge at either end of the closed highway or portion of highway and at such intermediate points along the detour, or detours as may be necessary to plainly mark the same. Upon completion of the work of construction, improvement or repair and as soon as the highway or bridge constructed or repaired shall be in suitable condition for public travel, all barriers, marks and signs whatsoever erected under the provisions hereof shall be at once removed by the officials erecting or replacing the same."

6H. APPLICATION OF DEVICES

6H-1 TYPICAL APPLICATIONS

Section 6H presents typical application diagrams for a variety of situations commonly encountered. The typical applications include the use of various traffic control methods, but do not include a layout for every conceivable work situation. Typical applications should, when necessary be altered to fit the conditions of a particular temporary traffic control zone. For example, work at an intersection may present a near-side work area for one street and a far-side work area for the other street. These treatments are found in two different diagrams, and a third diagram shows how to handle pedestrian crosswalk closures. Standards presented in Sections 6A-6F should be given priority over the examples given in the typical applications.

The typical applications illustrated in Section 6H generally represent minimum requirements. Other devices may be added to supplement the devices shown in the typicals, and sign spacings and taper lengths may be increased to provide additional time or space for driver reaction and response. In some situations, however, such as an urban setting, too many devices can spread signing over too long a distance to be meaningful.

Procedures for establishing temporary traffic control zones vary with such conditions as road configuration, location of the work, work activity, duration, traffic speed, traffic volume, and pedestrians. Examples presented in this chapter are guides showing how to apply principles and standards. Judgment is needed in applying these guidelines to actual situations and adjusting to field conditions. Where the situation being addressed is less than typical, actual conditions may require fewer devices.

Although portable barriers are frequently indicated in the typical applications of Section 6H, they are not traffic-control devices in themselves. However, when placed in a position identical to a line of channelizing devices and marked and/or equipped with appropriate channelizing features to give guidance and warning both day and night, they serve as traffic-control devices and, therefore, must conform to all requirements for such devices set forth throughout Part 6.

6H-2 ADDITIONAL AND/OR UPGRADING OF DEVICES

The typical designs may be modified to a more elaborate treatment as indicated by the following:

A. Additional devices

1. Additional signs
2. Flashing arrow panels
3. More channelizing devices at closer spacing
4. Temporary raised pavement markers
5. High-level warning devices
6. Portable changeable message signs
7. Temporary traffic signals
8. Portable barriers
9. Impact attenuators
10. Screens
11. Rumble strips

B. Upgrading of devices

1. A full complement of standard pavement markings in areas of high accident potential
2. Brighter and/or wider pavement markings
3. Larger signs
4. High-type channelizing devices
5. Barriers in place of channelizing devices

C. Improved geometrics at detours or crossovers, giving particular attention to the provisions set forth in Section 6B.

D. Increased distances

1. Longer advance warning area
2. Longer tapers

E. Lighting

1. Temporary roadway lighting
2. Steady-burn lights used with channelizing devices
3. Flashing lights for warning of isolated special conditions
4. Illuminated signs
5. Floodlights

When conditions are not as difficult or of less traffic crash potential as those depicted in the typicals, fewer devices may suffice. However, uniformity of devices and their application is always of paramount importance.

6H-3 TABLES

Tables that provide guidance for the development of a traffic control plan and the location and spacing of traffic control devices are presented again for reference. These are also in Section 6C of this document.

Page 6H-4	Table 6-1	Advance Sign Spacing Distances "D"
	Table 6-2	Guidelines for Length of Longitudinal Buffer Space "B"
Page 6H-5	Table 6-3	Taper Lengths for Temporary Traffic Control Zones "L"

Additional Notes for Tables

1. Speed is posted speed, off-peak 85th percentile speed prior to work starting, or the anticipated operating speed.

2. The use of a longitudinal buffer space is optional. If a longitudinal buffer space is used, it shall be completely free of all vehicle, equipment, workers and materials.

3. A longitudinal buffer space is included in the activity area and is shown in Figure 6-1 and Figure 6-2 on pages 6C-5 and 6C-6.

4. The length of the longitudinal buffer space is based upon American Association of State Highway and Transportation Officials (AASHTO) braking distance portion of stopping sight distance for wet and level pavements (A Policy on Geometric Design of Highways and Streets, AASHTO. This AASHTO document also recommends adjustments for the effect of grade on stopping and variation for trucks.

TABLE 6-1

DISTANCE BETWEEN TRAFFIC CONTROL DEVICES "D"

"D" DISTANCES	POSTED SPEED LIMIT, MPH (PRIOR TO WORK AREA)									
	25	30	35	40	45	50	55	60	65	70
D (FEET)	250	300	350	400	450	500	550	600	650	700
D (METERS)	76.2	91.4	106.7	121.9	137.2	152.4	167.6	182.9	198.1	213.4

TABLE 6-2

GUIDELINES FOR LENGTH OF LONGITUDINAL BUFFER SPACE[1] "B"

SPEED* MPH	LENGTH FEET	LENGTH METERS
20	33	10
25	50	15
30	83	25
35	132	40
40	181	55
45	230	70
50	279	85
55	329	100
60	411	125
65	476	145
70	542	165

* POSTED SPEED, OFF PEAK 85TH PERCENTILE SPEED PRIOR TO WORK STARTING, OR THE ANTICIPATED OPERATING SPEED

1 BASED UPON AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) BRAKING DISTANCE PORTION OF STOPPING SIGHT DISTANCE FOR WET AND LEVEL PAVEMENTS (A POLICY ON GEOMETRIC DESIGN OF HIGHWAY AND STREETS), AASHTO. THIS AASHTO DOCUMENT ALSO RECOMMENDS ADJUSTMENTS FOR THE EFFECT OF GRADE ON STOPPING AND VARIATION FOR TRUCKS.

TABLE 6-3

MINIMUM MERGING TAPER LENGTH "L" (FEET)

OFFSET	POSTED SPEED LIMIT, MPH (PRIOR TO WORK AREA)										
FEET	25	30	35	40	45	50	55	60	65	70	TAPER LENGTH "L" IN FEET
1	10	15	20	27	45	50	55	60	65	70	
2	21	30	41	53	90	100	110	120	130	140	
3	31	45	61	80	135	150	165	180	195	210	
4	42	60	82	107	180	200	220	240	260	280	
5	52	75	102	133	225	250	275	300	325	350	
6	63	90	123	160	270	300	330	360	390	420	
7	73	105	143	187	315	350	385	420	455	490	
8	83	120	163	213	360	400	440	480	520	560	
9	94	135	184	240	405	450	495	540	585	630	
10	104	150	204	267	450	500	550	600	650	700	
11	115	165	225	293	495	550	605	660	715	770	
12	125	180	245	320	540	600	660	720	780	840	
13	135	195	266	347	585	650	715	780	845	910	
14	146	210	286	374	630	700	770	840	910	980	
15	157	225	307	400	675	750	825	900	975	1050	

MINIMUM MERGING TAPER LENGTH "L" (METERS)

OFFSET		POSTED SPEED LIMIT, MPH (PRIOR TO WORK AREA)										
METERS	FEET	25	30	35	40	45	50	55	60	65	70	TAPER LENGTH "L" IN METERS
0.3	0.9843	3.1	4.5	6.1	8.0	13.5	15.0	16.5	18.0	19.5	21.0	
0.6	1.9686	6.3	9.0	12.3	16.0	27.0	30.0	33.0	36.0	39.0	42.0	
0.9	2.9529	9.4	13.5	18.4	24.0	40.5	45.0	49.5	54.0	58.5	63.0	
1.2	3.9372	12.5	18.0	24.5	32.0	54.0	60.0	66.0	72.0	78.0	84.0	
1.5	4.9215	15.6	22.5	30.6	40.0	67.5	75.0	82.5	90.0	97.5	105.0	
1.8	5.9058	18.8	27.0	36.8	48.0	81.0	90.0	99.0	108.0	117.0	126.0	
2.1	6.8901	21.9	31.5	42.9	56.0	94.5	105.0	115.5	126.0	136.5	147.0	
2.4	7.8744	25.0	36.0	49.0	64.0	108.0	120.0	132.0	144.0	156.0	168.0	
2.7	8.8587	28.1	40.5	55.1	72.0	121.5	135.0	148.5	162.0	175.5	189.0	
3.0	9.8430	31.3	45.0	61.3	80.0	135.0	150.0	165.0	180.0	195.0	210.0	
3.3	10.8273	34.4	49.5	67.4	88.0	148.5	165.0	181.5	198.0	214.5	231.0	
3.6	11.8116	37.5	54.0	73.5	96.0	162.0	180.0	198.0	216.0	234.0	252.0	
3.9	12.7959	40.6	58.5	79.6	104.0	175.5	195.0	214.5	234.0	253.5	273.0	
4.2	13.7795	43.8	63.0	85.8	112.0	189.0	210.0	231.0	252.0	273.0	294.0	
4.5	14.7638	46.9	67.5	91.9	120.0	202.5	225.0	247.5	270.0	292.5	315.0	

THE FORMULAS FOR THE MINIMUM LENGTH OF A MERGING TAPER IN DERIVING THE "L" VALUES SHOWN IN THE ABOVE TABLES ARE AS FOLLOWS:

$$"L" = \frac{W \times S^2}{60}$$ WHERE POSTED SPEED PRIOR TO THE WORK AREA IS 40 MPH OR LESS

"L" = S x W WHERE POSTED SPEED PRIOR TO THE WORK AREA IS 45 MPH OR GREATER

L = MINIMUM LENGTH OF MERGING TAPER
S = POSTED SPEED LIMIT IN MPH PRIOR TO WORK AREA
W = WIDTH OF OFFSET

TYPES OF TAPERS	TAPER LENGTH
UPSTREAM TAPERS	
MERGING TAPER	L - MINIMUM
SHIFTING TAPER	1/2 L - MINIMUM
SHOULDER TAPER	1/3 L - MINIMUM
TWO-WAY TRAFFIC TAPER	100' - MAXIMUM
DOWNSTREAM TAPERS (USE IS OPTIONAL)	100' - MINIMUM (PER LANE)

6H-4 TYPICAL APPLICATION DIAGRAMS

1. Typical application diagrams are included for the following categories of highway type:

   a. Rural two-lane roadways, see figures 6-10, 6-11, 6-13, 6-19, 6-20 and 6-21.

   b. Urban arterials, see figures 6-12, 6-14, 6-15, and 6-18.

   c. Other urban streets, see figures 6-22 and 24.

   d. Rural or urban multi-lane divided and undivided highways, see figures 6-14, 6-15, 6-16, 6-17, 6-18, 6-29, 6-30, and 6-31.

   e. Intersections, see figures 6-23, 6-24, 6-25, 6-26, 6-27, and 6-28.

   f. Freeways, see figures 6-29, 6-30, 6-31, 6-32, and 6-33.

2. Features which may be added to the diagrams - The measures described below are useful in increasing the attention-getting properties and the visibility of traffic-control devices.

   a. Flags on signs

      Flags may be placed above signs to enhance their target value and increase motorists' awareness. Flags are useful for daytime operations only.

   b. Flashing lights on signs

      Portable warning lights may be placed above signs to enhance their target value and increase motorists' awareness. Type A low-intensity warning lights are effective at night. Type B high-intensity warning lights are effective for both day and night.

   c. Sign illumination

      The retro-reflective material used on sign faces returns light to a light source. Some road users, such as pedestrians and cyclists, may not have any or adequate head lamps. Where these situations are encountered, adequate nighttime sign visibility may be obtained using internal or external sign illumination.

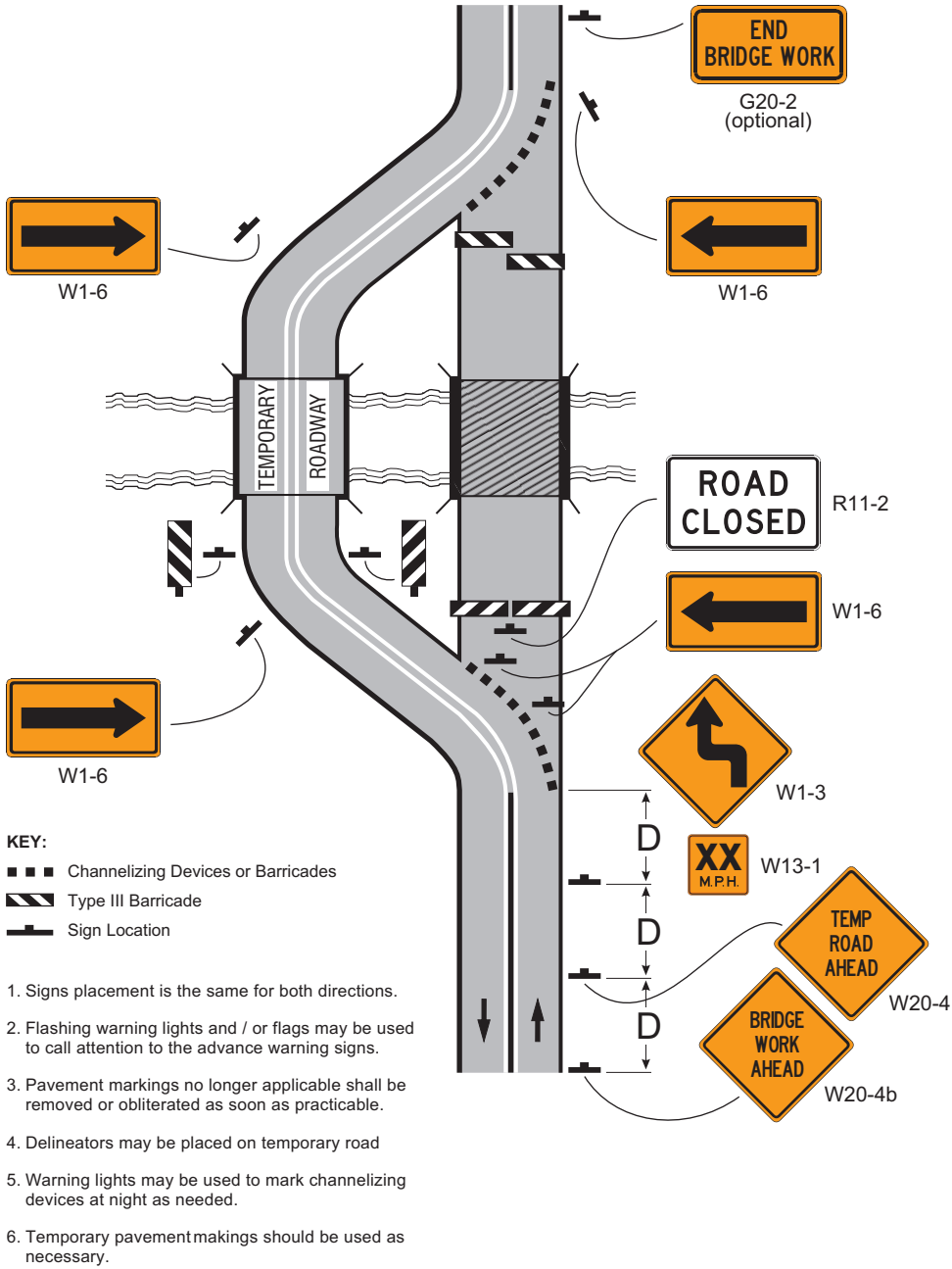
   d. Lights on channelizing devices

      For intermediate and long-term operations, consideration should be given to placing portable warning lights on channelizing devices. Lights are especially effective in the following applications: where new travel patterns are established at tapers, shifts, and run-around; at road closures; on devices placed on horizontal and vertical curves; where headlights may not adequately illuminate retro-reflective material on channelizing devices; and where adverse weather conditions are anticipated.

Table 6-4 is an index of typical applications illustrated. The remainder of the chapter also contains two pages for field notes. The typical application diagrams are listed with notes on the same page.

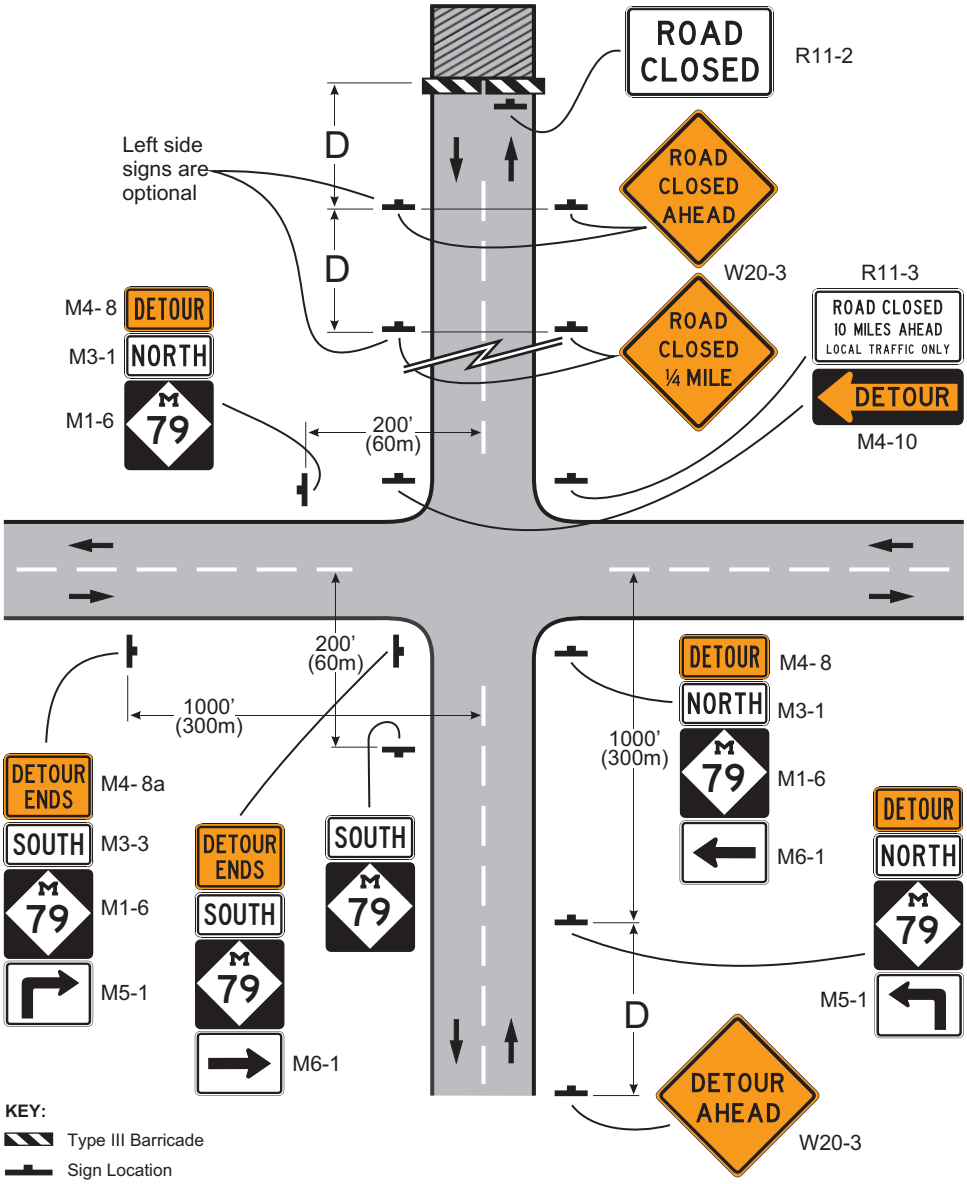
Table 6-4 Index to Typical Application Figures

Traffic Control Type	Geometry	Figure Number
Temporary Road Around a Work Site	2 lane 2 way	6-10
Trunkline Detour	2 lane 2 way	6-11
Detour in an Urban Area	2 lane 2 way	6-12
Traffic Regulating (Flagging) with Two Stations	2 lane 2 way	6-13
Single-Lane Closure	4 lane 2 way	6-14
Double-Lane Closure	4 lane 2 way	6-15
Freeway Reconstruction with Two-Lane Two-Way (2L2W)	4 lane divided	6-16
Single-Lane Closure - Short Term Stationary	4 lane divided	6-17
Double-Lane Closure	4 lane 1 way	6-18
One-Lane Closure at a Spot Location	2 lane 2 way	6-19
Spot Locations- Single Traffic Regulator	2 lane 2 way	6-20
Temporary Signals	2 lane 2 way	6-21
Work in the Center of the Road	2 lane 2 way	6-22
Center Closure - Short Duration	3/2/ lane 2 way	6-23
Right Lane Closure on Far Side of Intersection	4 lane 2 way	6-24
Left-Lane Closure on Far Side of Intersection	4 lane 2 way	6-25
Two Lanes Closed at an Intersection	4 lane 2 way	6-26
Work in Center of Intersection, Low-Volume Roads Only	2 lane 2 way	6-27
Traffic Regulator at an Intersection	2 lane 2 way	6-28
Shoulder Closure Enroaching Roadway	Freeway and X-way	6-29
On-Ramp Staging Freeway Reconstruction	Freeway and X-way	6-30
Off-Ramp Stages for Paving	Freeway and X-way	6-31
On-Ramp Stages for Paving	Freeway and X-way	6-32
Ramp Shoulder	Freeway and X-way	6-33
Pedestrian Detour	Urban with walks	6-34
Pedestrian Walk Closure	Urban with walks	6-35
Shoulder Closure	2 lane 2 way	6-36



1. Signs placement is the same for both directions.
2. Flashing warning lights and / or flags may be used to call attention to the advance warning signs.
3. Pavement markings no longer applicable shall be removed or obliterated as soon as practicable.
4. Delineators may be placed on temporary road
5. Warning lights may be used to mark channelizing devices at night as needed.
6. Temporary pavement makings should be used as necessary.

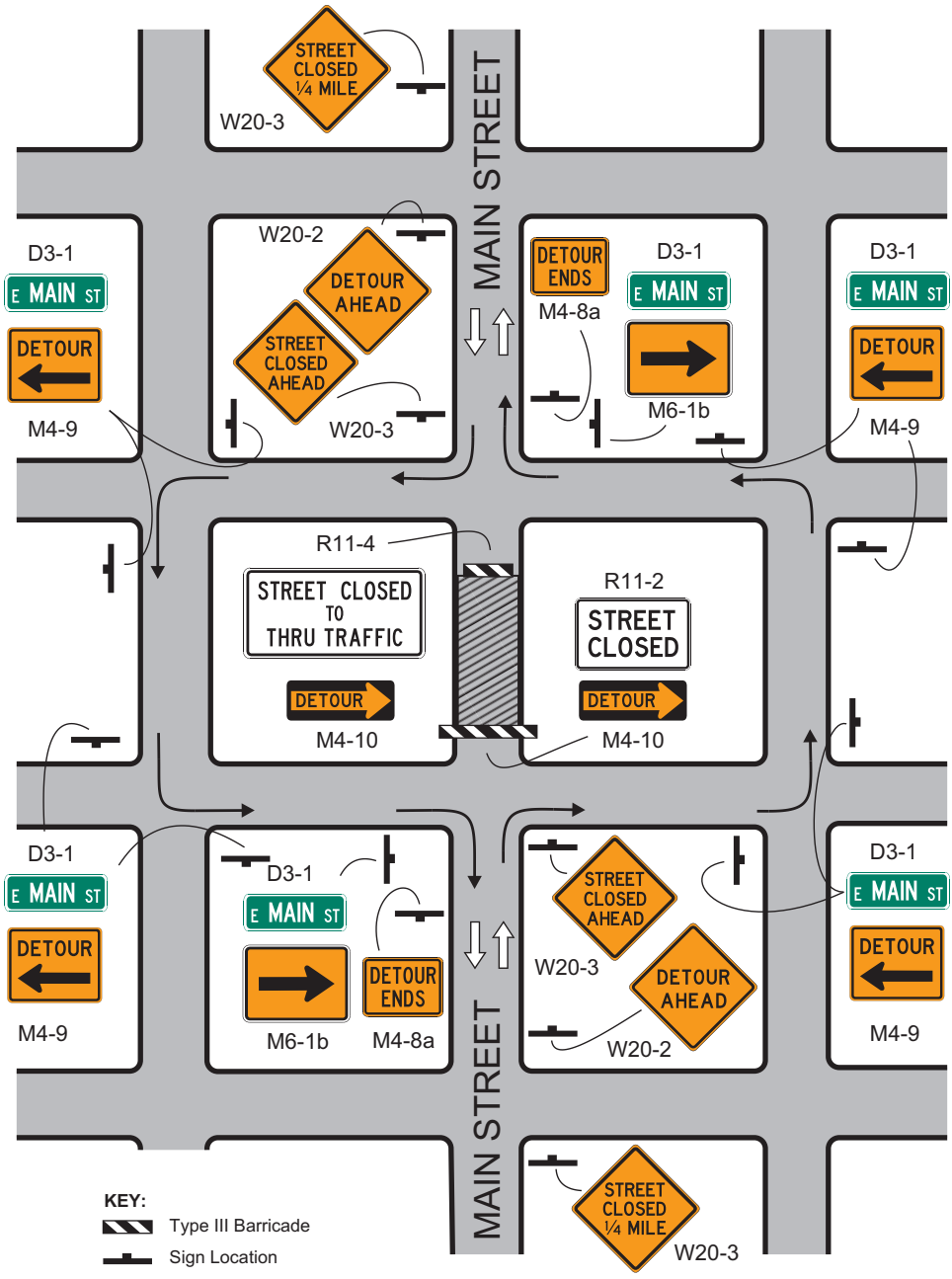
Figure 6-10. Temporary Road Around a Work Site.



1. Additional signing may be required on the crossroad to advise the motorists of the detour.

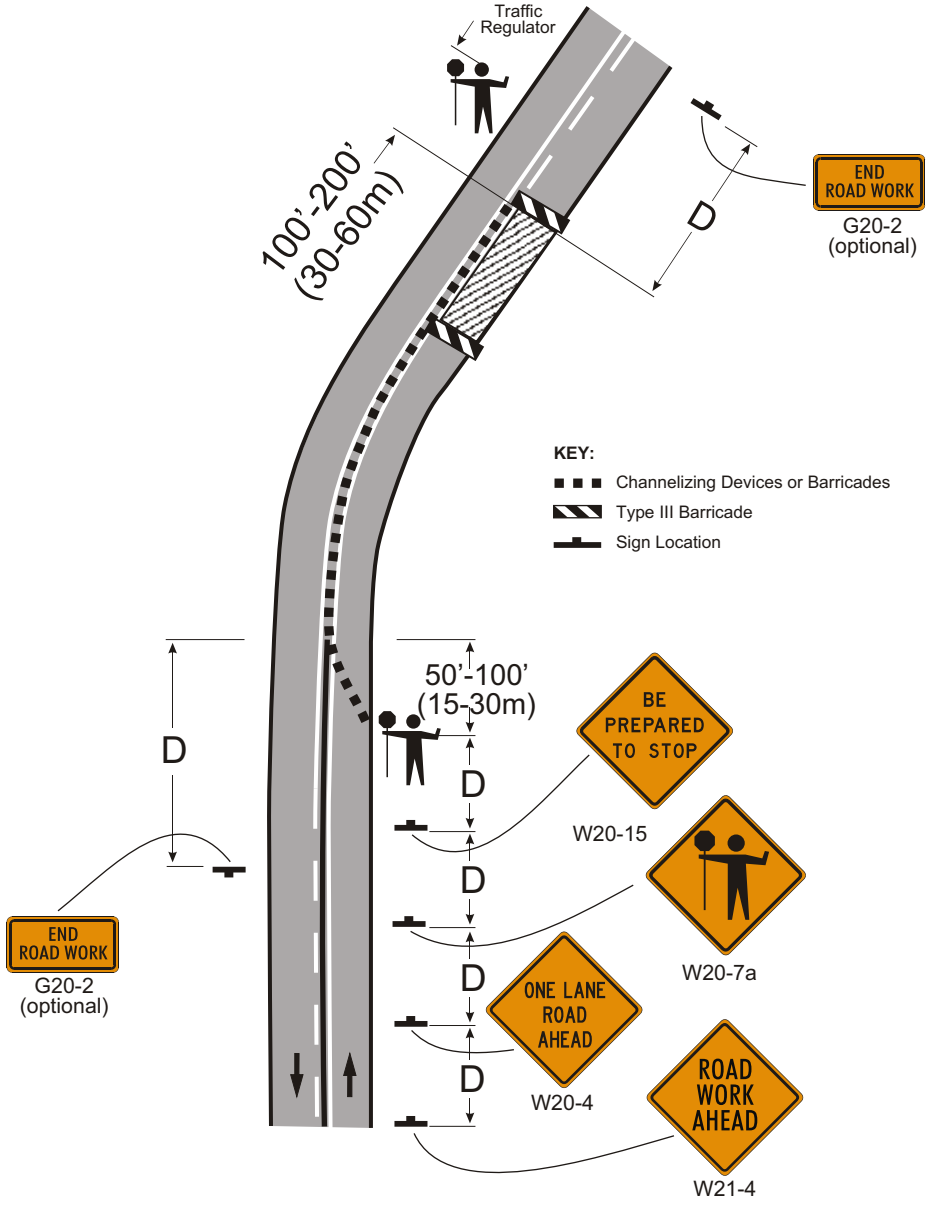
2. If the road is closed a short distance beyond the intersection and there are few destination points beyond the intersection, the ROAD CLOSED and DETOUR signs may be placed on a Type III barricade placed in the center of the roadway.

Figure 6-11. Trunkline Detour.



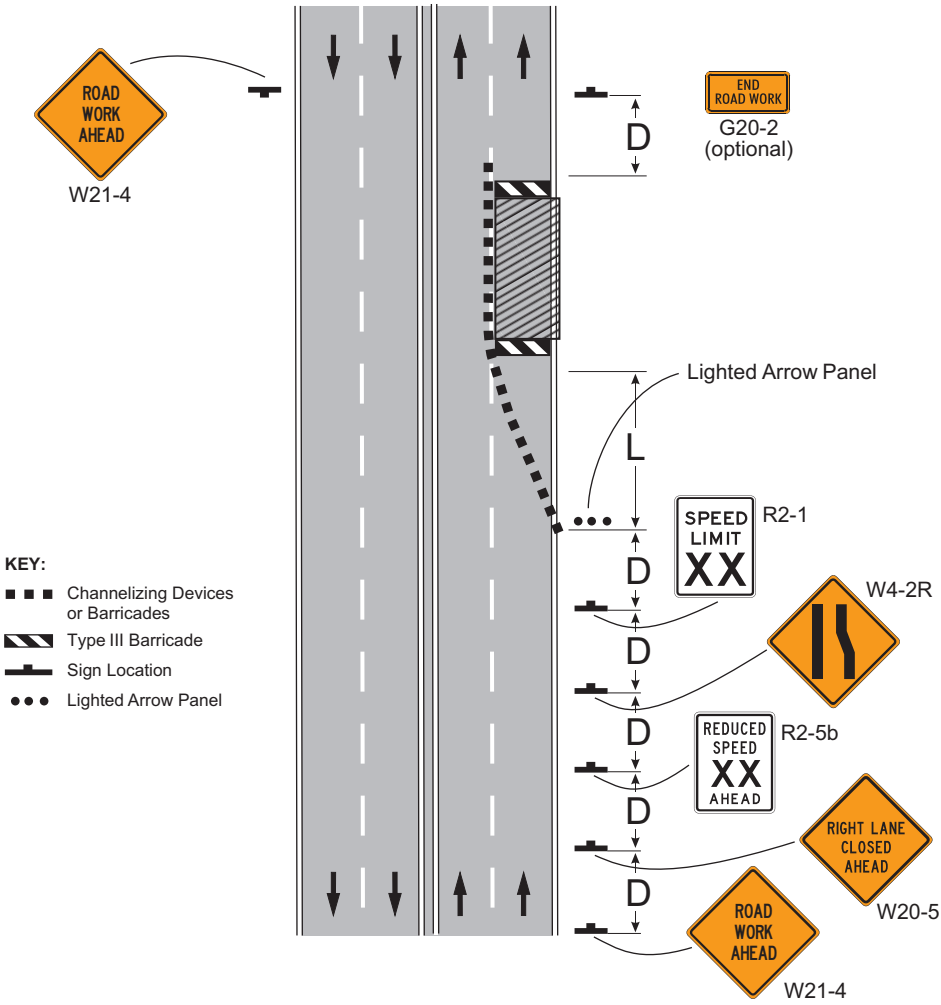
1. Additional signing may be required on the crossroad to advise the motorists of detour.

Figure 6-12. Detour in an Urban Area.



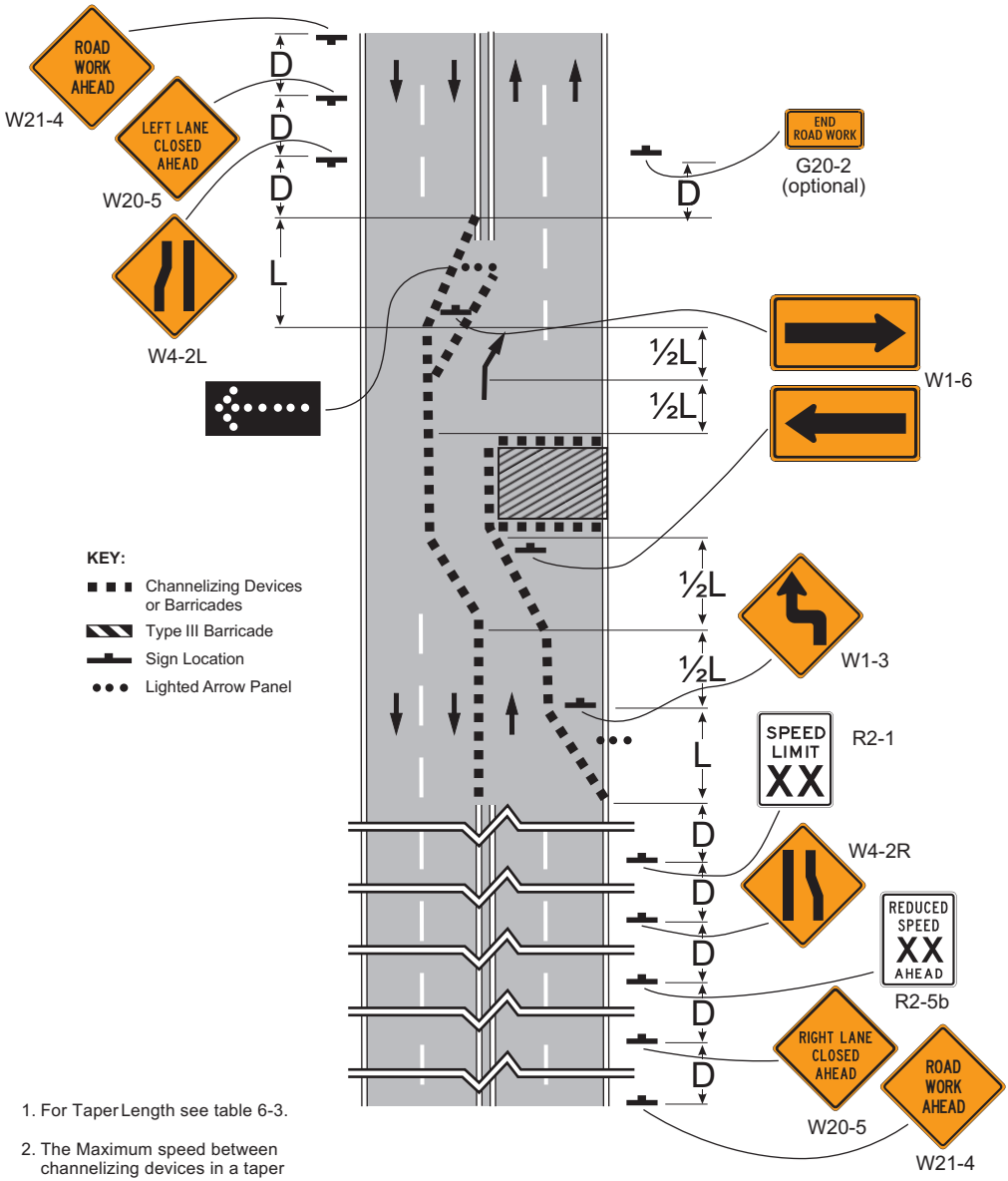
1. Signs placement is the same for both directions.
2. Flood lights are required to illuminate traffic regulator stations at night.
3. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
4. Channelizing devices are to be extended to a point where they are visible to approaching traffic.
5. A lighted Arrow Panel should be used near the traffic regulator (Caution mode).

Figure 6-13. Traffic Regulating (Flagging) with Two Stations



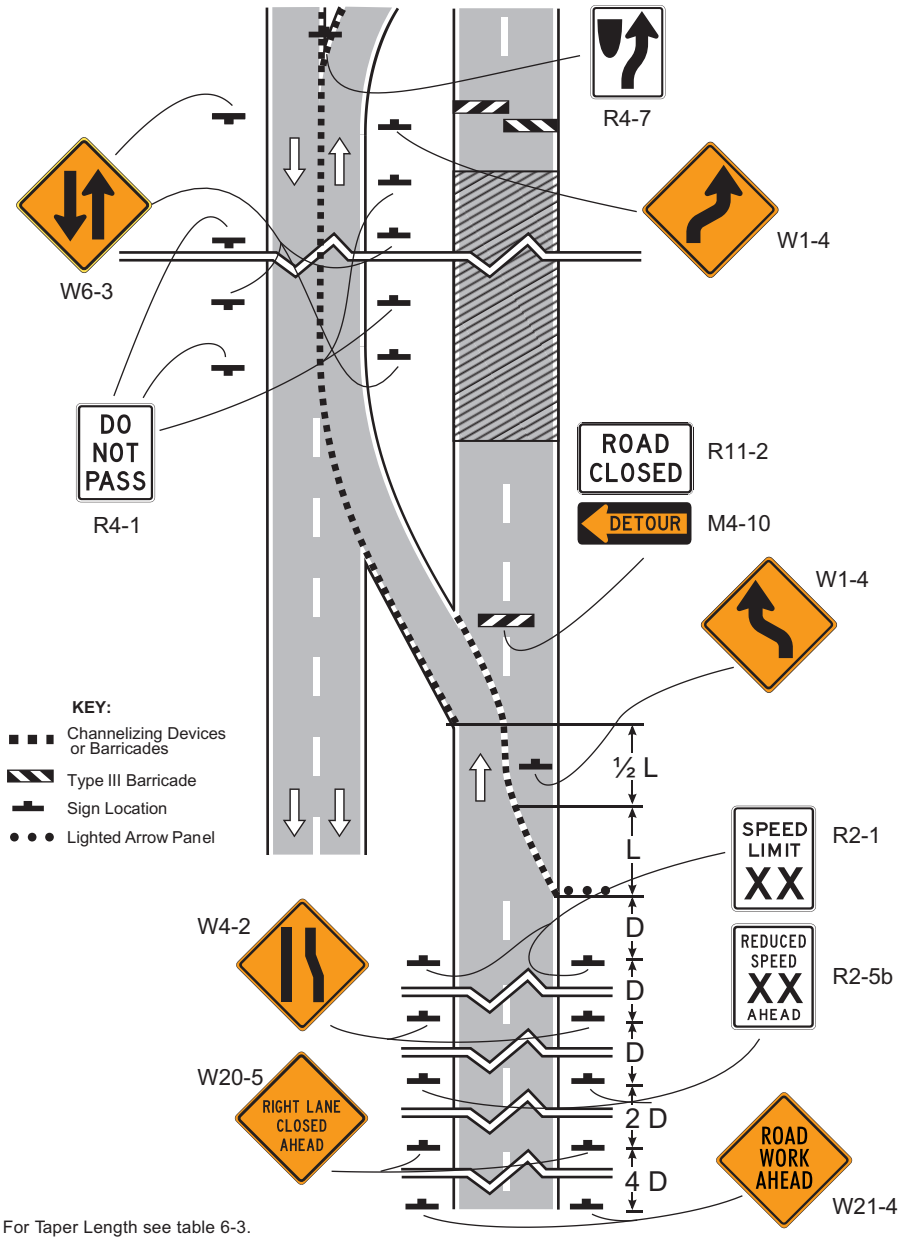
1. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
2. A Type II Barricade and Large Arrow Sign may be substituted for a Lighted Arrow Panel.
3. For Taper Length see table 6-3.
4. SPEED LIMIT signs should be used in the advance signing when necessary.

Figure 6-14. Single Lane Closure



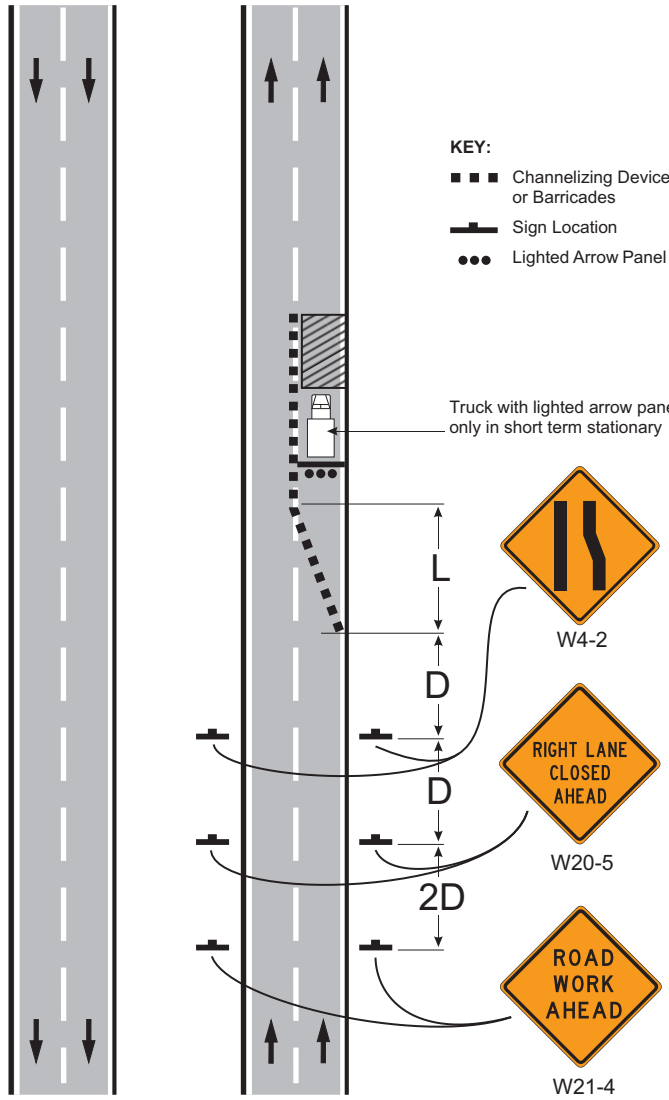
1. For Taper Length see table 6-3.
2. The Maximum speed between channelizing devices in a taper should be approximately equal in 1/3 the speed limit in feet.
3. Pavement markers no longer applicable shall be removed or obliterated as soon as practicable. Temporary markings shall be used as necessary.
4. Warning lights should be used to mark channelizing devices at night as needed.
5. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
6. SPEED LIMIT signs should be used in advance signing when necessary.

Figure 6-15. Double Lane Closure



1. For Taper Length see table 6-3.
2. Pavement markings no longer applicable shall be removed or obliterated as soon as practicable.
3. Warning lights should be used to mark channelizing devices at night as needed.
4. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.
5. SPEED LIMIT signs should be used in the advance signing when necessary.

Figure 6-16. Freeway Reconstruction with Two-Lane Two-Way (2L2W).



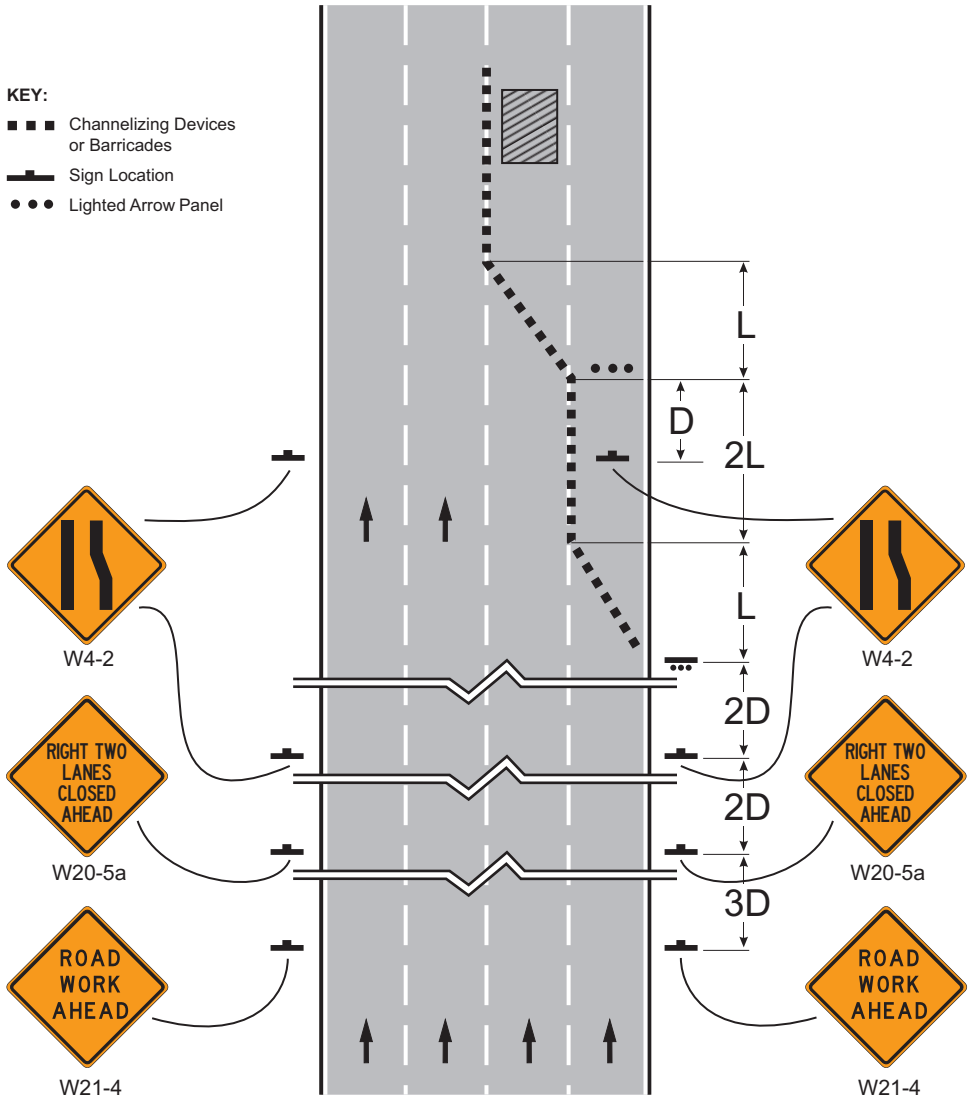
1. For Taper Length see table 6-3.

2. The maximum spacing between channelizing devices in a taper should be approximately equal in feet to the speed limit.

3. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.

4. SPEED LIMIT signs should be used in the advanced signing when necessary.

Figure 6-17. Single Lane Closure - Short Term Stationary.



1. For Taper Length see table 6-3.

2. The maximum spacing between channelizing devices in a taper should be approximately equal in feet to the speed limit.

3. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.

4. SPEED LIMIT signs should be used in the advanced signing when necessary.

Figure 6-18. Double Lane Closure.

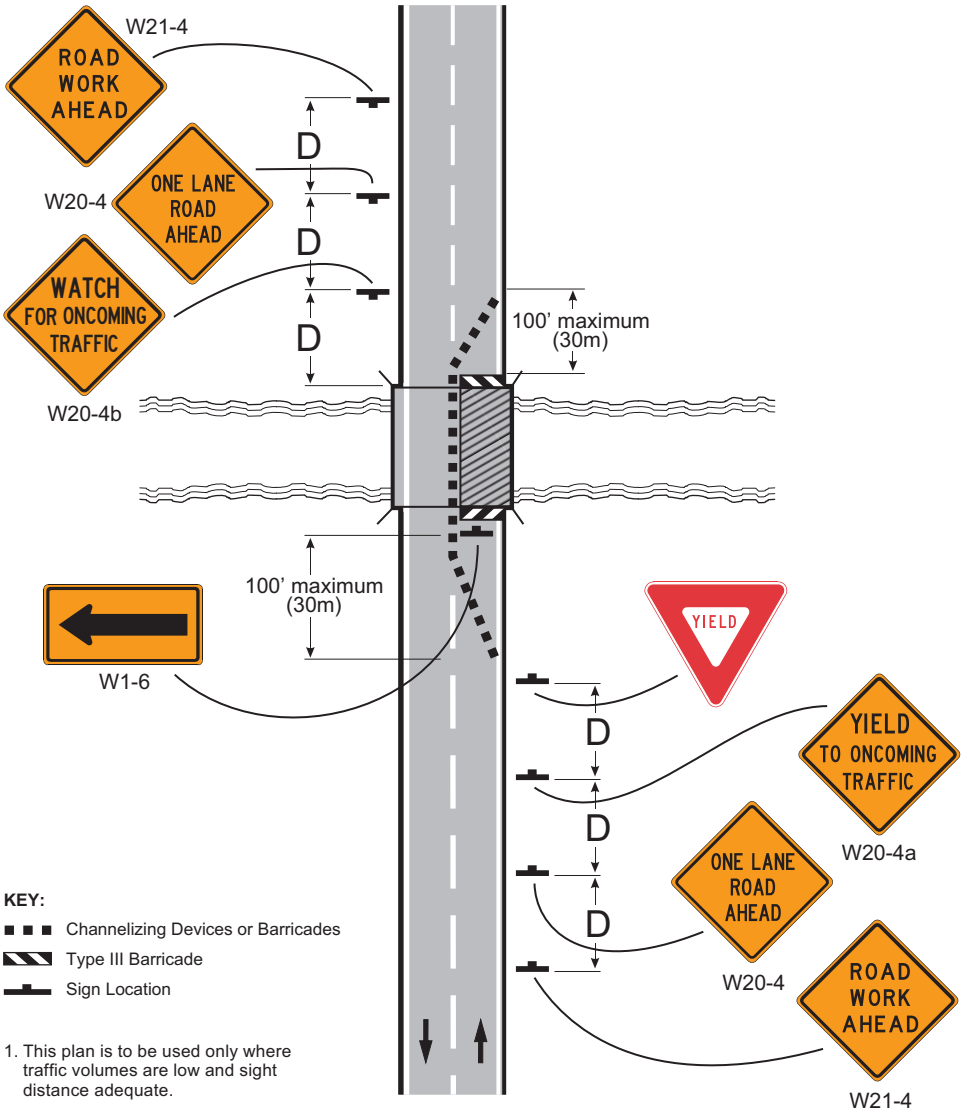
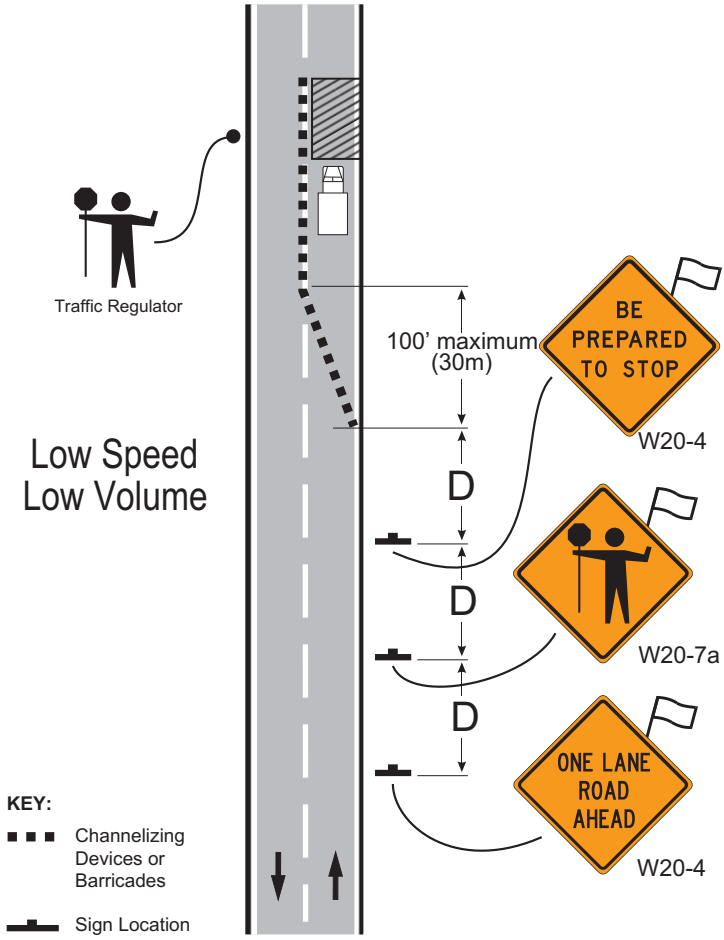


Figure 6-19. One Lane Closure at a Spot Location.



1. When one lane of a two-lane, two-way roadway is closed for work, two traffic regulators are ordinarily required. However the condition shown above using only one traffic regulator may be appropriate if the following conditions are met. See Traffic Regulators Instruction Manual pg. 18.

   A. the work area is short (guardrail ending, minor shoulder repair)
   B. the work area is on a straight section of road with good visibility from both approaches
   C. traffic volumes are low
   D. traffic speeds are low

2. Signs are the same for both directions.

3. The work vehicle shall have either barricade markings of flashing (alternating) or rotating lights.

4. At least one standard orange warning flag should be positioned over each warning sign used for these operations.

5. These plans do not preclude provision of additional traffic control devices nor the control of speed and parking when approved by the appropriate highway authority.

Figure 6-20. Spot Locations-Single Traffic Regulator..

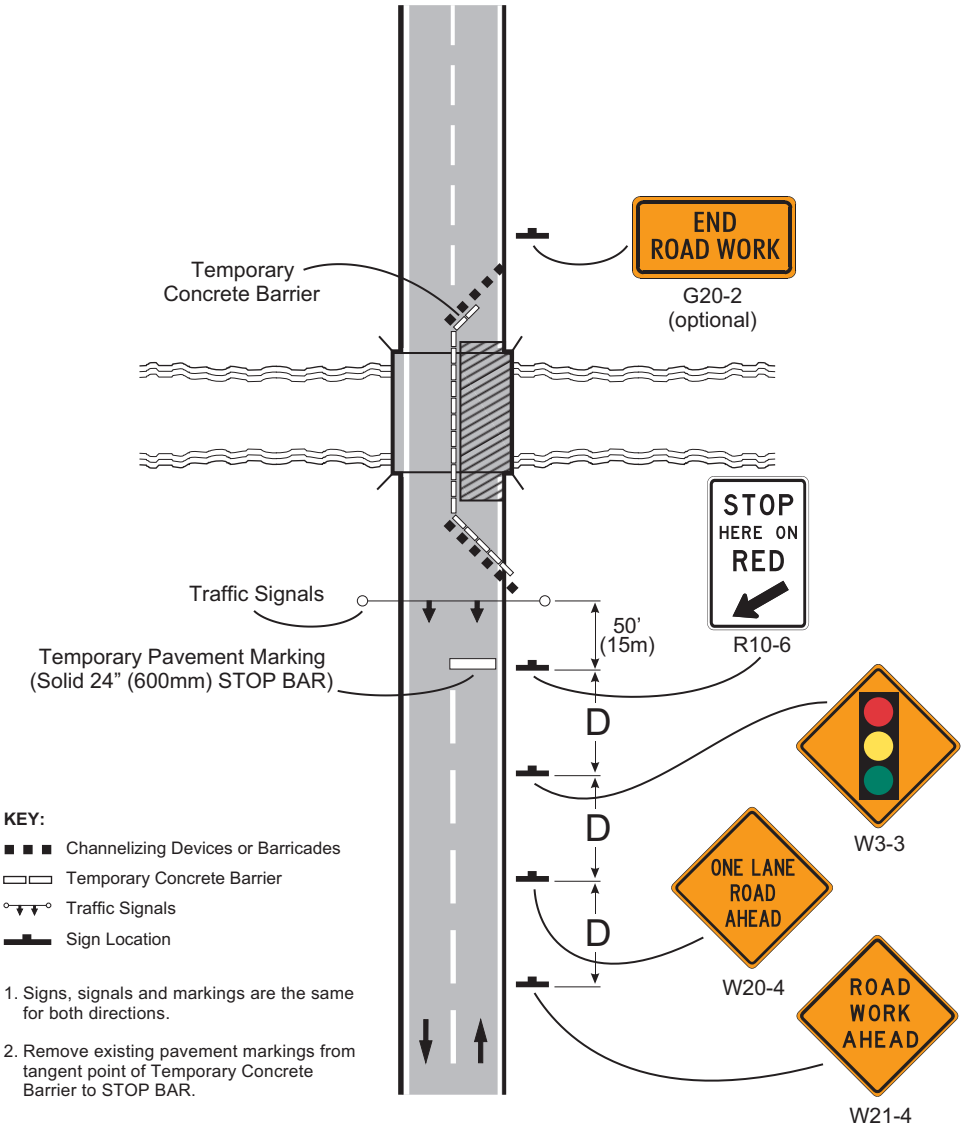
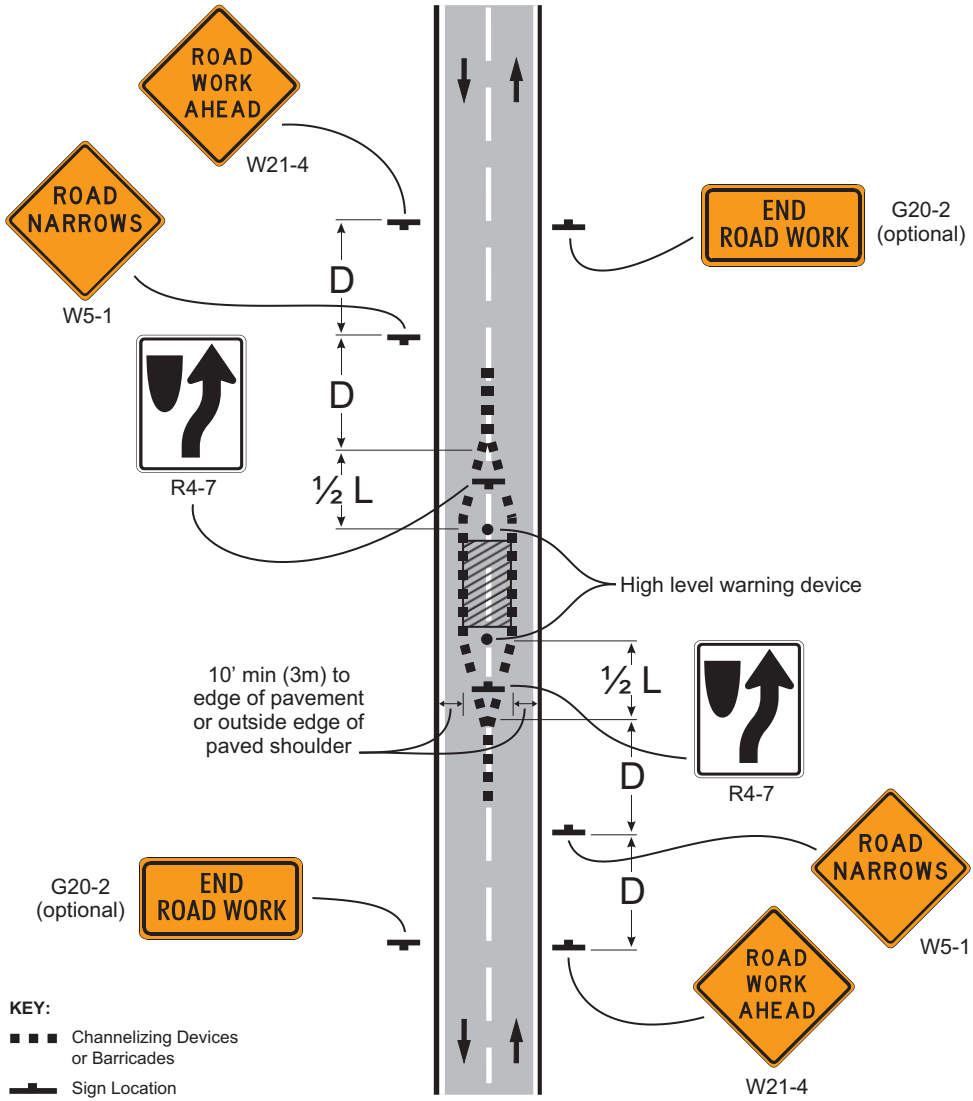


Figure 6-21. Temporary Signals.



1. For Taper Length see table 6-3.

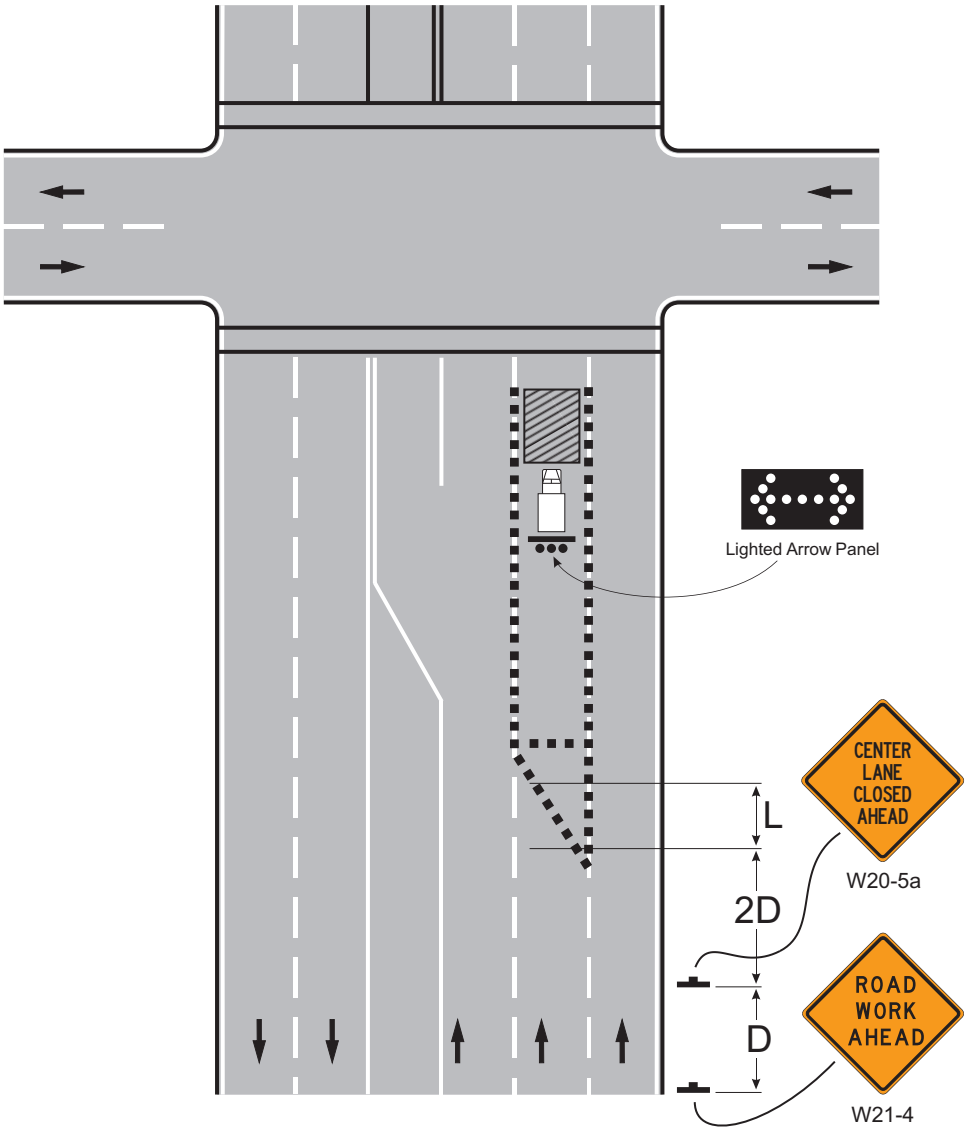
2. The lanes on either side of the center work space should have a minimum width of 10 feet, as measured form the near edge of the channelizing devices to the edge of pavement, or the outside edge of paved shoulder.

3. A minimum of six channelizing devices should be used for each taper. However, a work vehicle displaying a flashing revolving or strobe yellow lights may be used instead of the tapers.

4. Flashing warning lights and/or flags may be used to mark channelizing devices.

5. If the closure continues overnight, warning lights may be used to mark channelizing devices.

Figure 6-22. Work in the Center of the Road.



1. If the work space extends across the crosswalk, then close the cross-walk using the procedure and devices shown in figure 6-34.

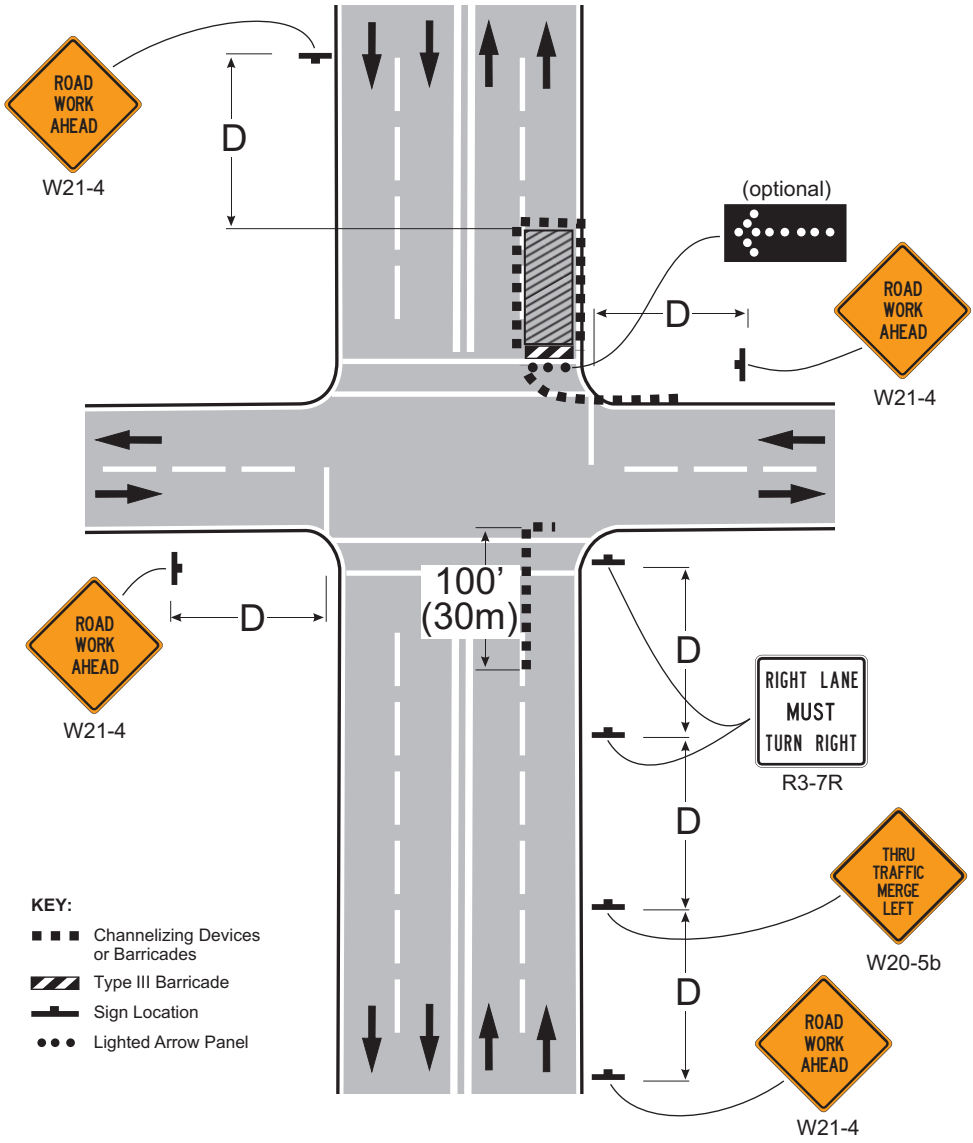
2. Flashing warning lights and/or flags may be used to call attention to the advance warning signs.

3. The merging taper may direct traffic into either the right or left lane but not both. In this typical, a left taper should be used so that right-turn movements will not impede traffic.

KEY:

- Channelizing Devices or Barricades
- Sign Location
- Lighted Arrow Panel

Figure 6-23. Center Closure - Short Duration.

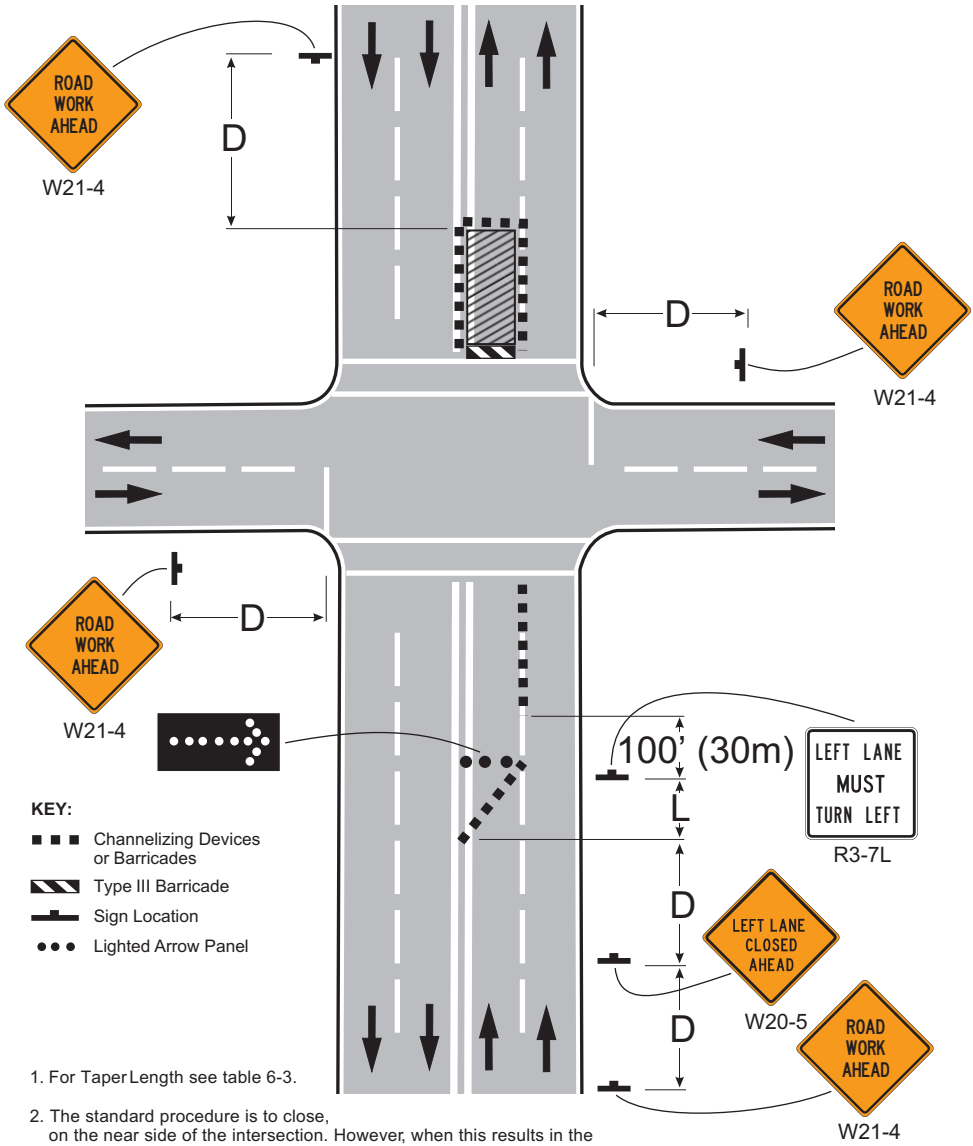


1. The standard procedure is to close on the near side of the intersection any lane that is not carried through the intersection. However, when this results in the closing of a right lane having significant right-turning movements, then the right lane may be restricted to right turns only, as shown. This procedure increases the through capacity by eliminating right turns from the open through lane.

2. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in figure 6-34.

3. Flashing warning lights and / or flags may be used to call attention to the advance warning signs.

Figure 6-24. Right Lane Closure on Far Side of Intersection



1. For Taper Length see table 6-3.

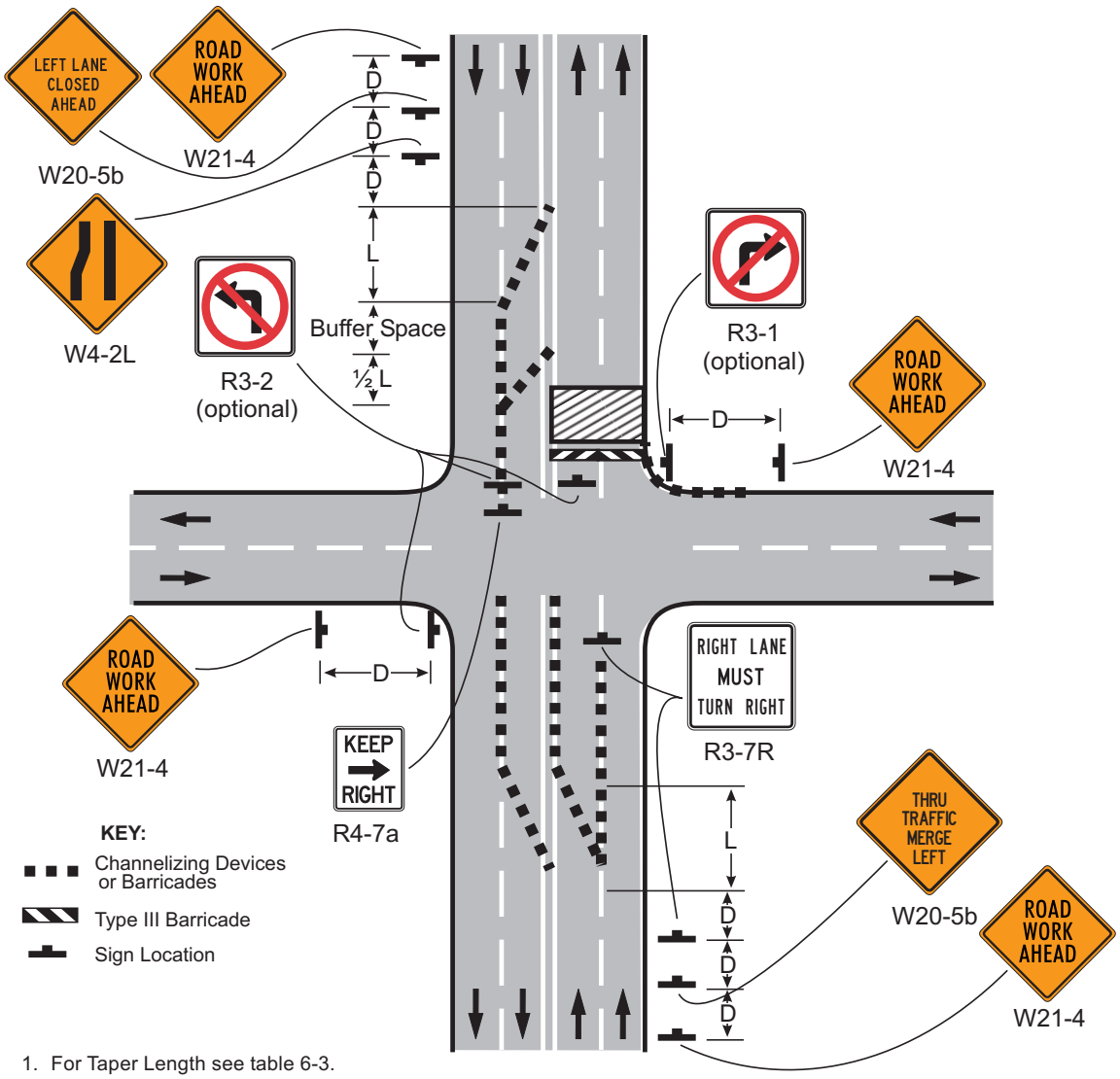
2. The standard procedure is to close, on the near side of the intersection. However, when this results in the closure of a left lane having significant left-turning movements, the left lane may be converted to a turn bay for left turns only, as shown by first closing off the left lane and then reopening is as a turn bay.

3. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in figures 6-34 & 6-35.

4. Care should be taken to warn drivers of vision obstructions for left-turning vehicles caused by equipment, material, and work operations in the work area.

5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

Figure 6-25. Left Lane Closure on Far Side of Intersection



1. For Taper Length see table 6-3.

2. For intersection approaches reduced to a single lane, left turning movements may be prohibited to maintain capacity for through traffic.

3. The standard procedure is to close on the near side of the intersection any lane that is not carried through the intersection. Therefore, the right lane should be closed on the near--side approach. However, if there is a significant right-turning movement, then the right lane may be restricted to right turns only, as shown. This procedure increases the through capacity by eliminating right turns from the open through lane.

4. Where the turning radius is large, it may be possible to create a right-turn island using channelizing devices, as shown. This procedure reinforces the nature of the temporary exclusive right-turn and enables a second RIGHT LANE MUST TURN RIGHT sign to be place in the island.

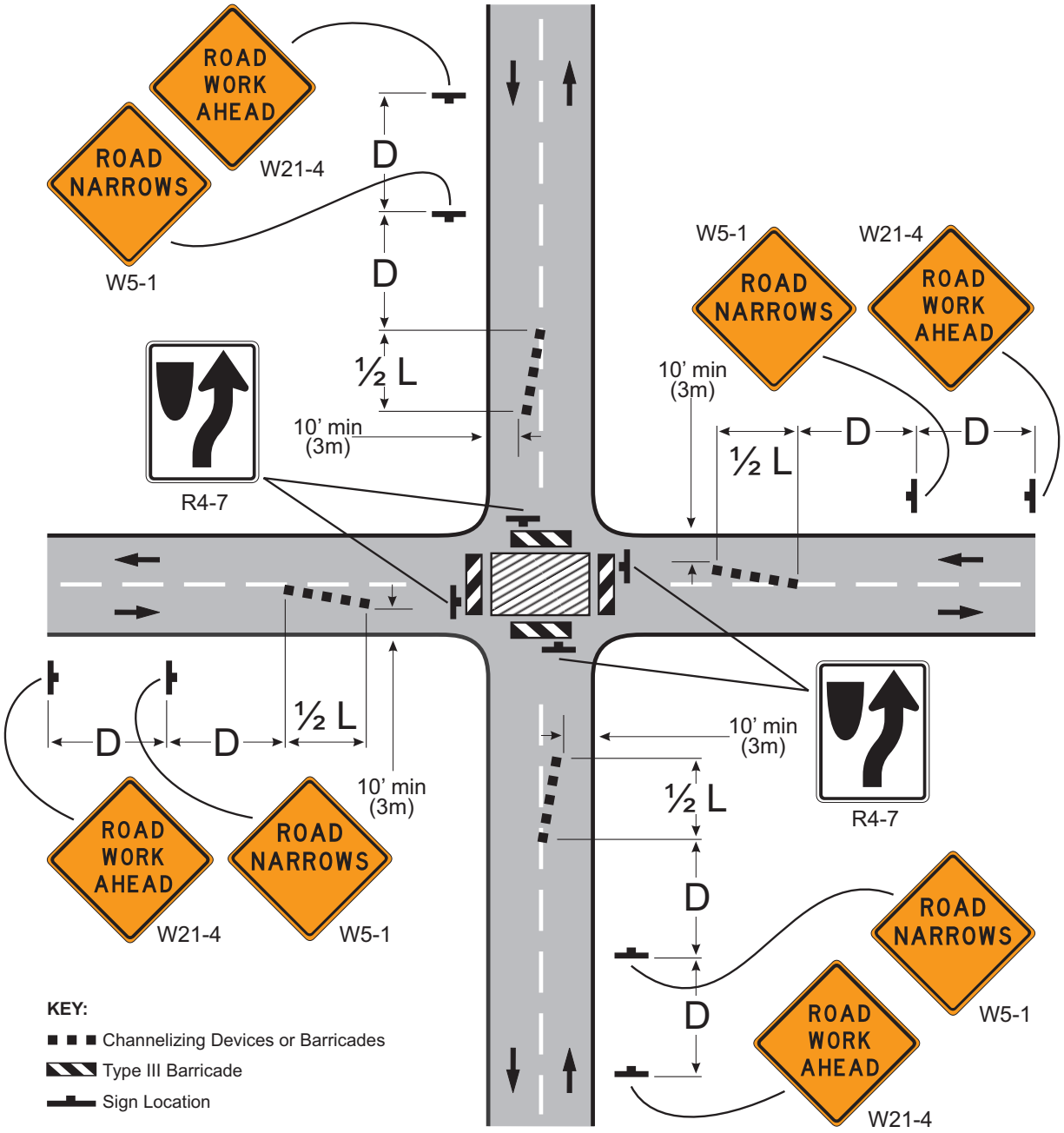
5. If the work space extends across a crosswalk, then close the crosswalk using the procedure and devices shown in figure 6-34.

6. A buffer space should be used between opposing directions of traffic as shown in this application.

7. There may be insufficient space to place the back-to-back KEEP RIGHT sign and NO LEFT TURN symbol signs at the end of the row of channeling devices separating opposing traffic flows. In this situation, place the NO LEFT TURN symbol sign on the right and omit the KEEP RIGHT sign.

8. Flashing warning lights and/or flags may be used to call attention to advanced warning signs.

Figure 6-26. Two Lanes Closed at an Intersection.



1. For Taper Length see table 6-3.

2. Prohibit left turns as required by traffic conditions. Unless the streets are wide, it may be physically impossible to turn left, especially for large vehicles.

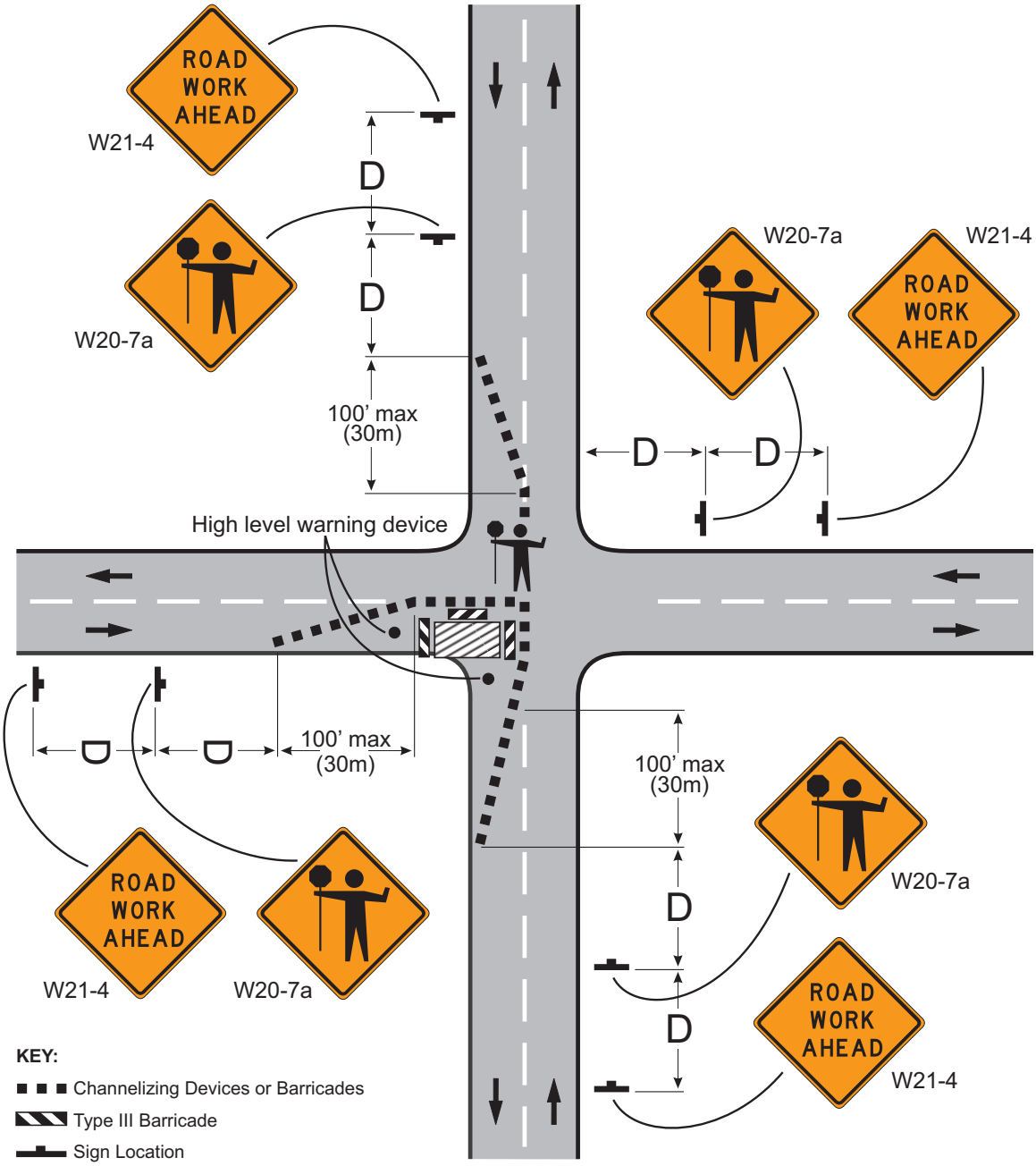
3. A minimum of six channelizing devices shall be used for each taper.

4. For short-duration work operations, the channelizing devices may be eliminated if a flashing or revolving yellow light is displayed in the work space.

5. A high level flag tree should be placed in the work space if there is sufficient room.

6. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

Figure 6-27. Work in Center of Intersection, Low Volume Roads Only.



1. For low traffic volumes and intersecting two-lane streets, one traffic regulator positioned in the center of the intersection may surface.

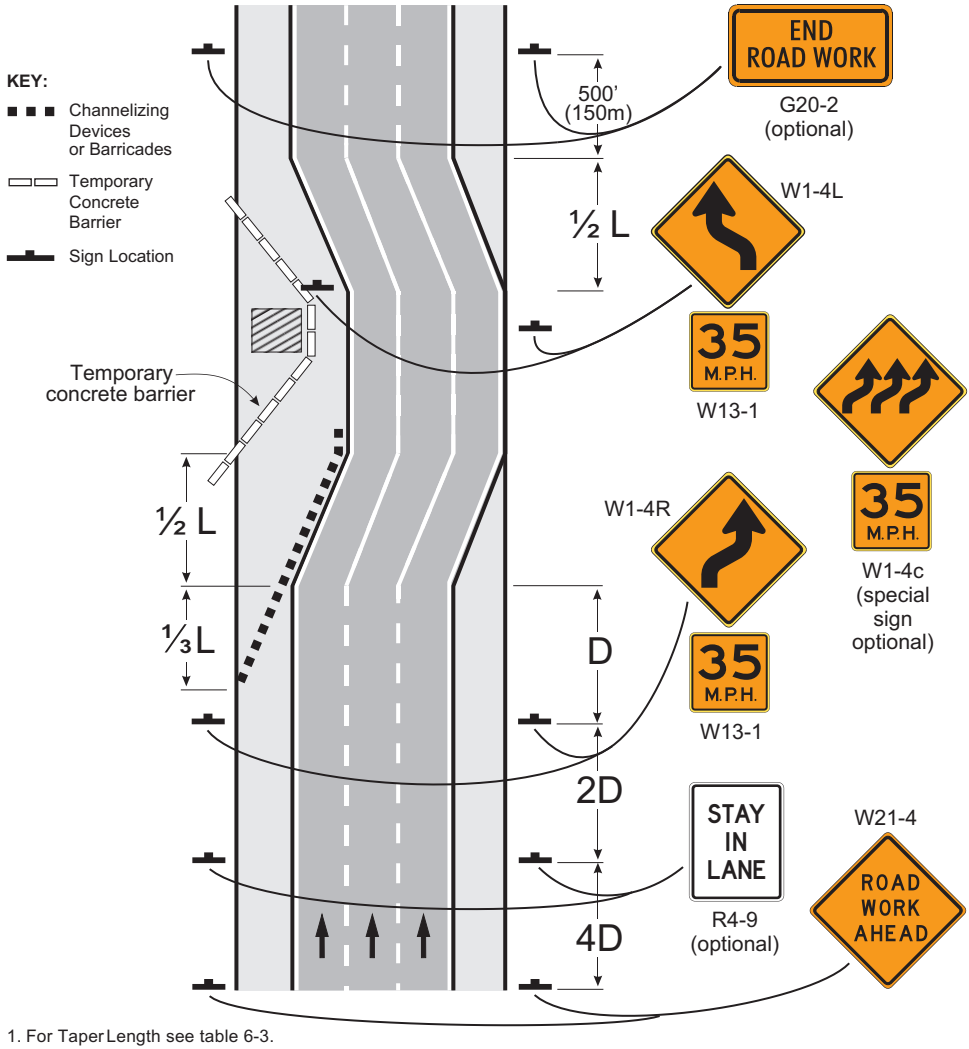
2. For high traffic volumes or when a four-lane street is involved, additional traffic regulators or law enforcement personnel may be used.

3. A ONE-LANE ROAD AHEAD sign may also be necessary to provide adequate advance warning.

4. The situation depicted can be simplified by closing one or more of the intersection approaches. If this cannot be done, and/or when capacity is a problem, consideration should be given to detouring through traffic.

5. Flashing warning lights and/or flags may be used to call attention to the advanced warning signs.

Figure 6-28. Traffic Regulator at an intersection.



1. For Taper Length see table 6-3.

2. Lane shifting should use: geometry which meets that design speed at which the permanent highway was designed. If this can be done, then no temporary traffic control devices may be needed other than the initial general work-zone warning signs. If a lesser alignment is used, additional warning signs and payment marking should be used.

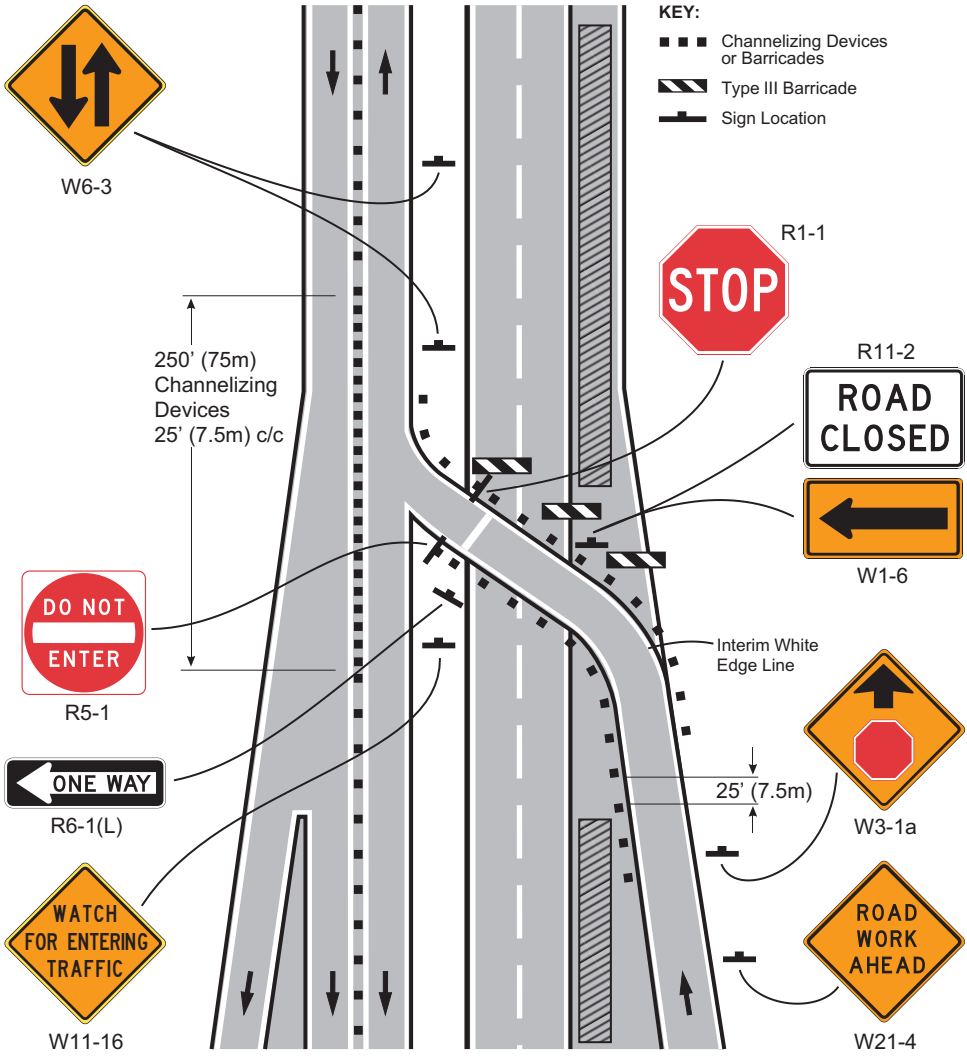
3. Where the shifted section is long, one set of REVERSE CURVE signs shows the initial shift and a second set shows the return to normal alignment. If the shift involves a short runaround, the W1-4c sign may be used.

4. If the STAY IN LANE sign is used, solid white lane lines should also be used.

5. The barrier shown is used to enclose a work area on long-term projects. Use of a barrier should be based on the need determined by an engineering analysis. The layout of the barrier should prevent vehicles from impacting the ends of the barrier. According to the Roadside Design Guide (RDS), the barrier should be flared beyond the clear zone. An alternative procedure is to place an impact attenuator to protect traffic from the end of the barrier.

6. Type C steady-burning warning lights may be placed on channelizing devices and the barrier parallel to the edge of pavement for nighttime lane closures. The maximum spacing should be identical to the channelizing device spacing.

Figure 6-29. Shoulder Closure Encroaching Roadway.



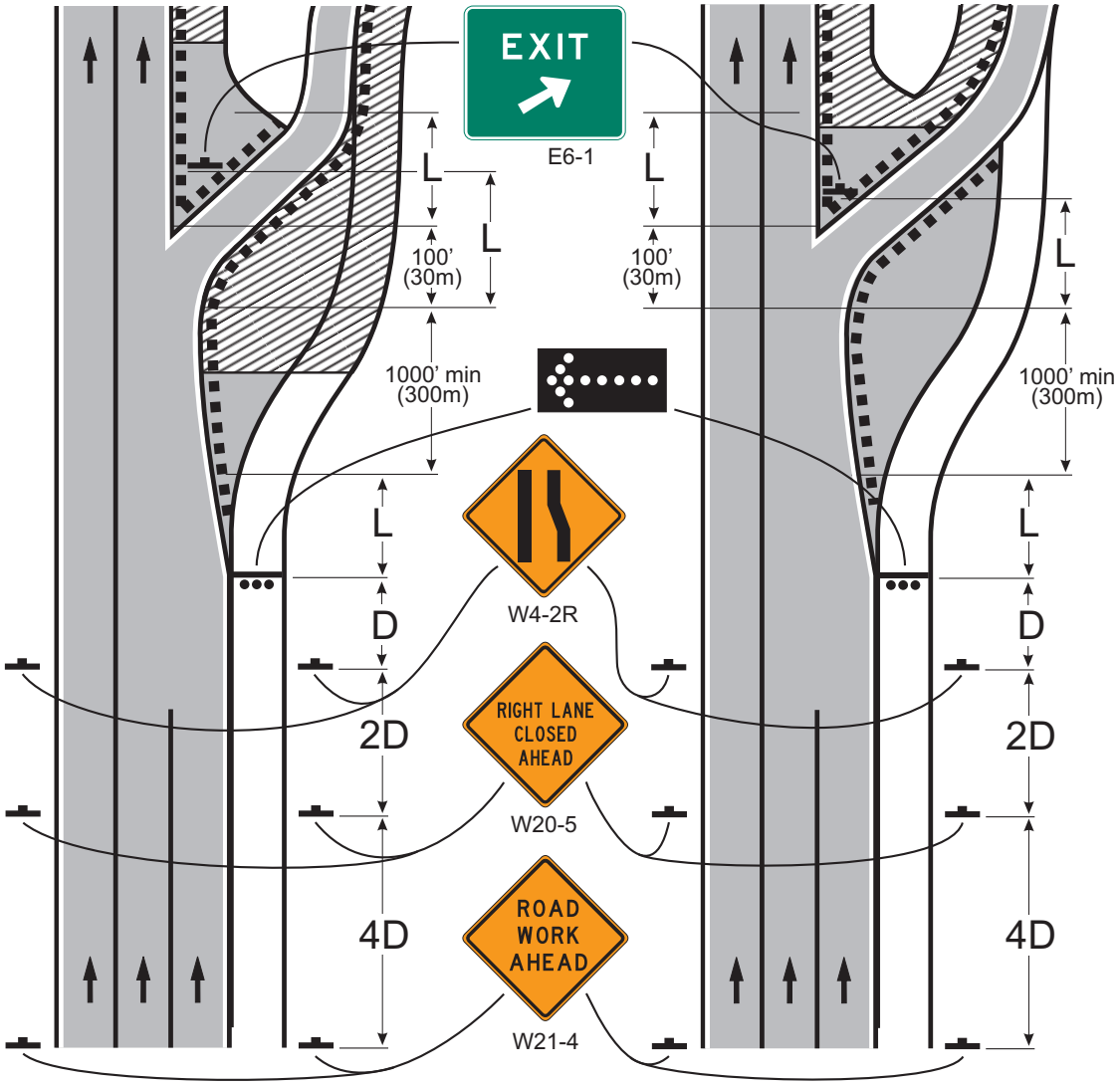
1. This diagram illustrates the procedure for carrying an entrance ramp across a closed directional roadway of a divided highway, if insufficient gaps are available, consideration should be given to closing the ramp. In some instances, a temporary acceleration lane may be useful in facilitating the merging maneuver.

2. The STOP sign should be located sufficiently far forward to provide adequate sight distance of oncoming mainline traffic to select a safe gap. Also, where feasible, acceleration distance should be provided beyond the stop location to reduce the gap size needed.

3. The temporary STOP sign should be turned to face ramp traffic and diminish its visibility to mainline traffic. Where view of the temporary STOP sign may be confusing to mainline traffic, a white-on-red supplementary plate may be added below, reading ON RAMP.

4. A temporary STOP line should be placed across the ramp at the desired stop location. Consideration should be given to placing a Type B high-intensity flasher with a red lens above the stop sign.

Figure 6-30. On Ramp Staging Freeway Reconstruction.



1. For Taper Length see table 6-3.

2. Additional advance warning may be necessary. The guide signing should indicate that the ramp is open, and where the temporary exit terminal is located. Conversely, if the ramp is closed the guide signing should also provide this information.

3. A buffer may be used.

4. An alternative is to channelize exiting traffic onto the right shoulder, and close the lane as necessary. The shoulder should be used only if it has sufficient width and structural capacity.

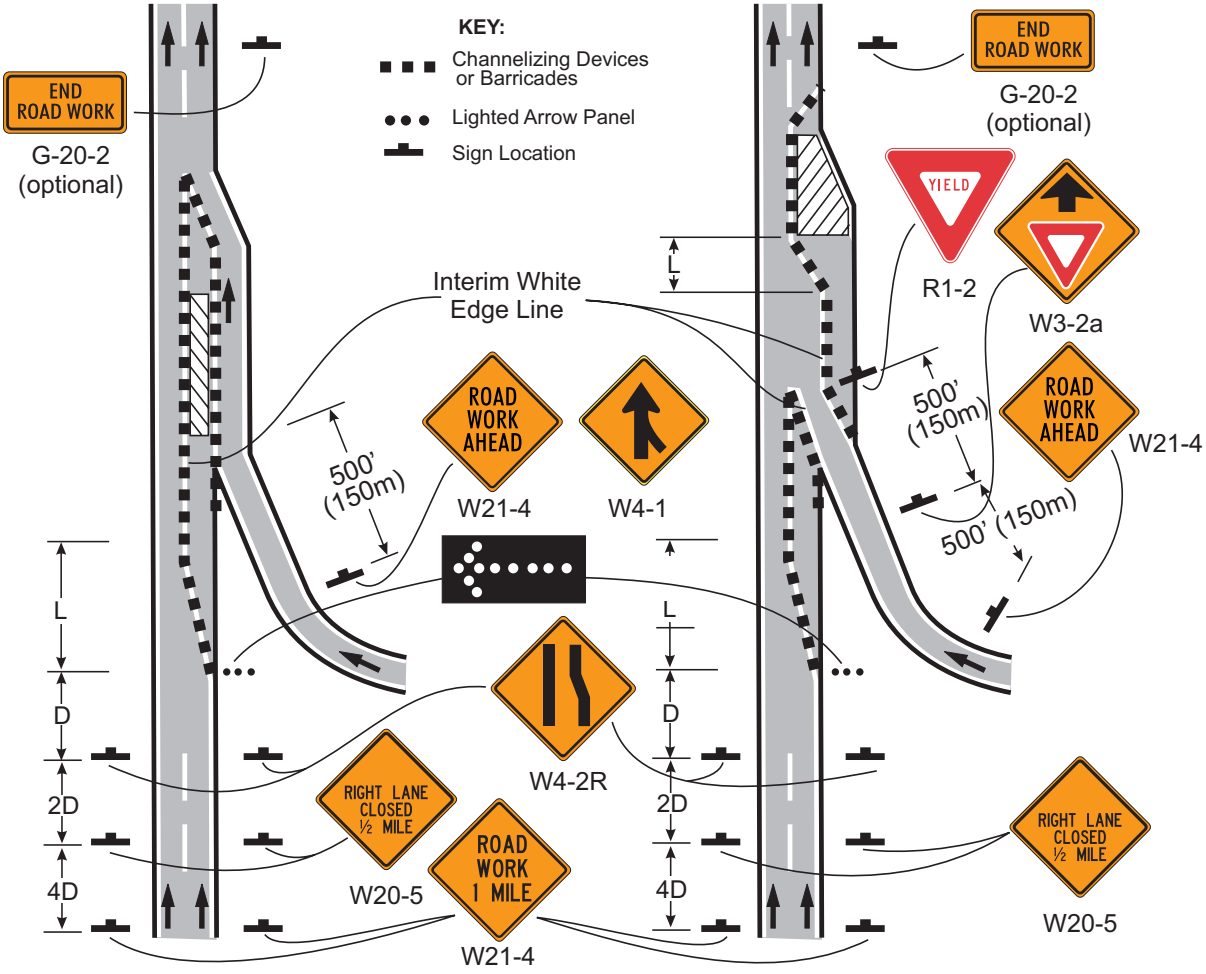
5. The temporary EXIT sign mounted in the temporary gore shall be clearly visible. It must be mount high enough so that it can be seen over the channeling devices. The mounting height for this sign shall be a minimum of 3' (1m) from the pavement surface to the bottom of the Sign.

6. If the exit is closed, this information should be clearly provided. An effective method is to place a black-on-orange plate reading EXIT CLOSED diagonally across the interchange/ intersection guide signs.

KEY:

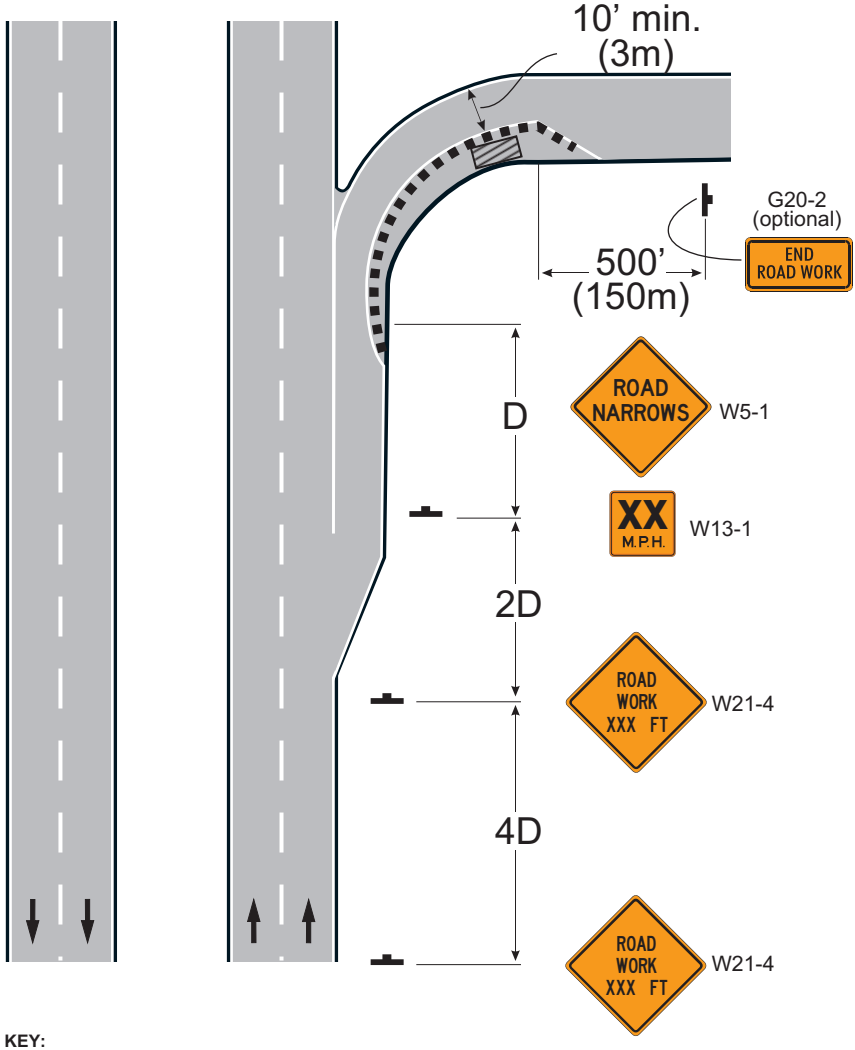
- Channelizing Devices or Barricades
- Sign Location
- Lighted Arrow Panel

Figure 6-31. Off Ramp Stages for Paving.



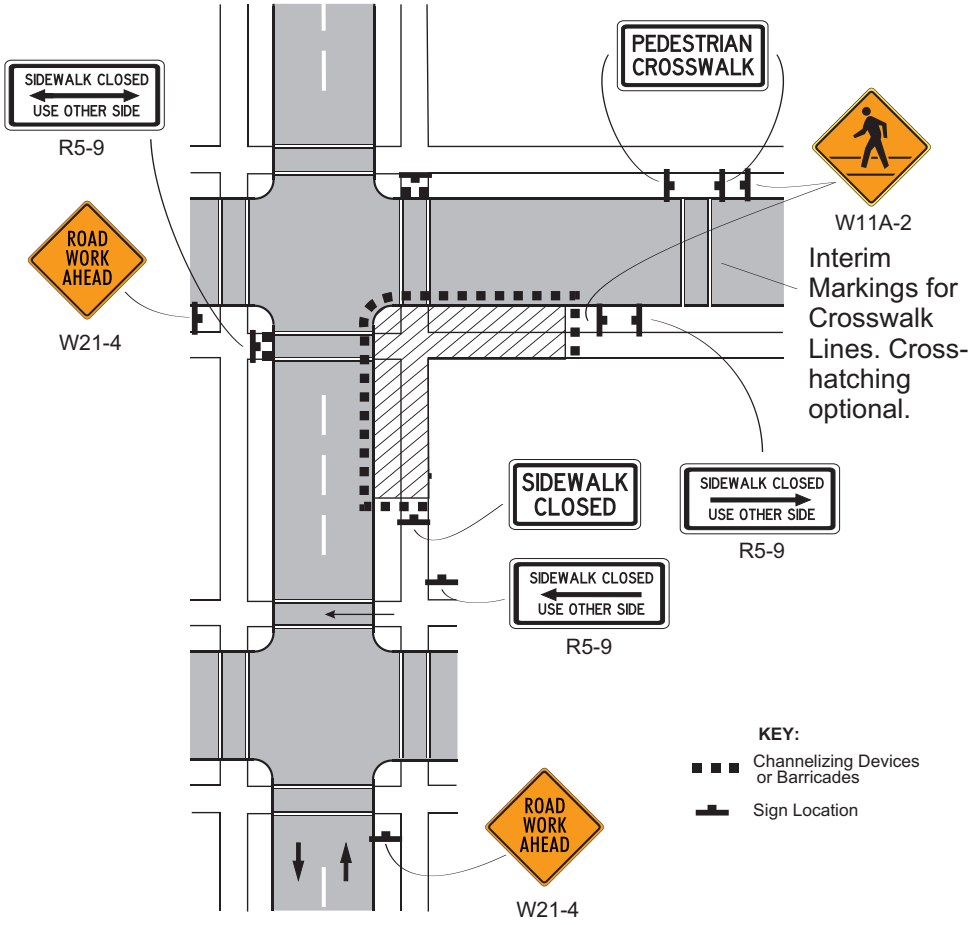
1. For Taper Length see table 6-3.
2. The right lane needs to be closed sufficiently far in advance to stabilize traffic flow before encountering the merge.
3. For the procedure shown on the right side of the diagram, the YIELD sign shall be replaced with STOP signs (one on each side of the approach), if no adequate acceleration lane exists for the temporary entrance. The STOP or YIELD sign should be located sufficiently far forward to provide adequate sight distance of oncoming mainline traffic in order to select a safe gap. Also, acceleration distance should be provided beyond the sign to reduce the gap size needed. If insufficient gaps are available, consideration should be given to closing the ramp.
4. Where STOP signs are used, a temporary stop line should be placed across the ramp at the desired stop location. Consideration should be given to placing a Type B high-intensity flasher with red lens above the stop sign.
5. The mainline merging taper with the arrow display at its starting point should be located sufficiently far upstream so that the arrow display is not confusing to motorists on the entrance ramp.
6. If the ramp curves sharply to the right, place pairs of signs (one on each side of the ramp) for warning signs located before the entrance terminal.
7. Where the acceleration distance is significantly reduced, a supplemental plate may be placed below the YIELD AHEAD sign, reading NO MERGE AREA.

Figure 6-32. On Ramp Stages for Paving.



1. Truck off-tracking should be considered when determining whether the 100 feet minimum lane width is adequate.

Figure 6-33. Ramp Shoulder



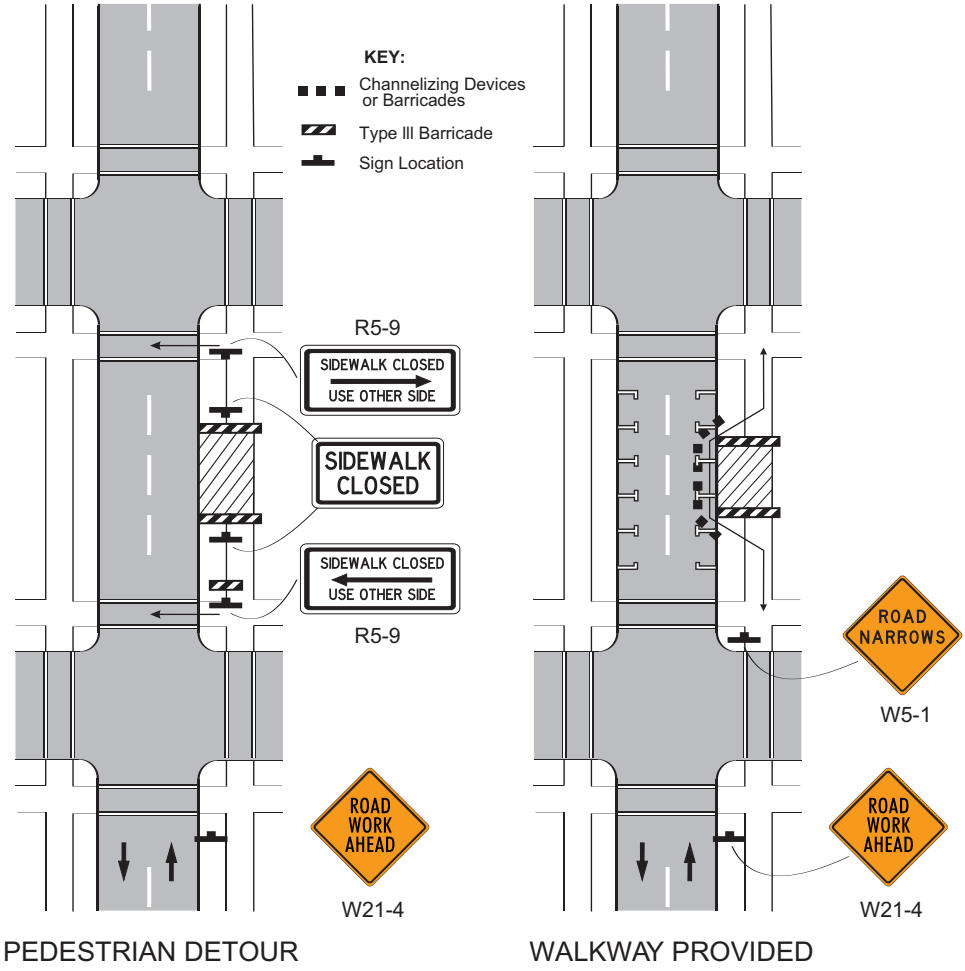
1. Only traffic control devices controlling pedestrian flows are shown. Other devices may be needed to control traffic on the streets. Use lane closure signing or ROAD NARROWS signs, as needed.

2. Street lighting should be considered.

3. For nighttime closures, Type A flashing warning lights may be used on barricades supporting signs and closing walkways. Type C steady-burn lights may be used on channelizing devices separating the temporary walkway from vehicular traffic.

4. Pedestrian traffic signal displays controlling closed crosswalks should be covered and deactivated.

Figure 6-34. Pedestrian Detour.



1. Additional advance warning may be necessary.

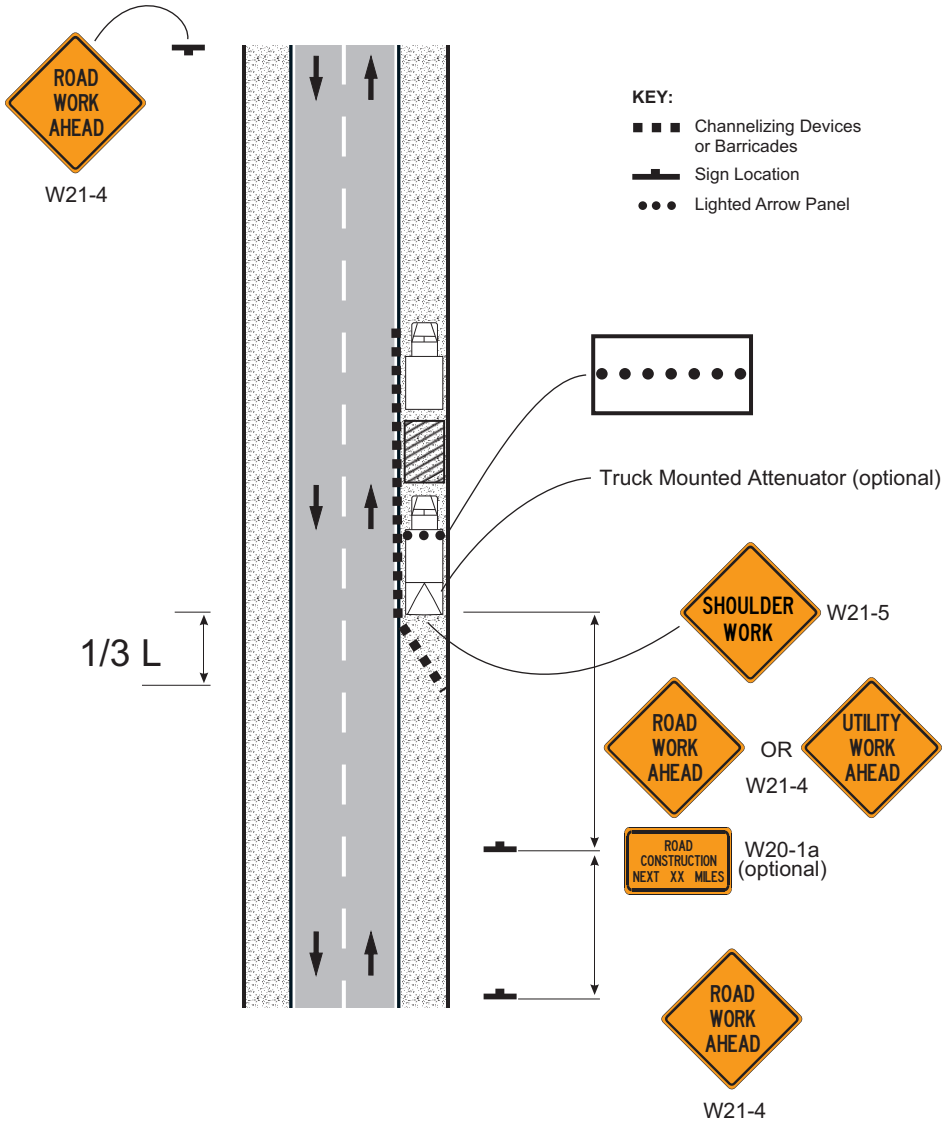
2. Only traffic control devices controlling pedestrian flows are shown. Other devices may be needed to control traffic on the streets. Use lane closure signing or ROAD NARROWS signs, as needed.

3. Street lighting should be considered.

4. For nighttime closures, Type A flashing warning lights may be used on barricades supporting signs and closing walkways. Type C steady-burn lights may be used on channelizing devices separating the temporary walkway from vehicular traffic.

5. Signs may be placed along a temporary walkway to guide or direct pedestrians. Examples include KEEP RIGHT and KEEP LEFT signs.

Figure 6-35. Pedestrian Walk Closure.



1. In situations where work is mobile it is impracticable to place stationary signs or a whole line of barricades surrounding the vehicles and work area.

2. If any barricades are utilized - consideration should be given to installing them in the taper.

3. For taper length see table 6-3.

Figure 6-36 Shoulder Closure